DOCTOR OF PHILOSOPHY

Investigating the environmental performance of government primary schools in Egypt with particular concern to thermal comfort

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Award date:
2009

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2009

University of Dundee

THESIS
2009.

University of Dundee
Dundee School of Architecture

College of Art, Science & Engineering

UNIVERSITY OF DUNDEE

INVESTIGATING THE ENVIRONMENTAL PERFORMANCE OF GOVERNMENT PRIMARY SCHOOLS IN EGYPT:

With particular concern to thermal comfort

By
Mady Mohamed

Dundee School of Architecture

A thesis submitted in partial fulfilment of the Requirements for the degree of Doctorate of Philosophy

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PULLOUTS

Appendices

Appendix 1:
Metabolic rates for different activities

Appendix 1: Metabolic rates for different activities [1]:

Table 1: Typical metabolic rate for various activities

Note:
1 Met = 58 W/m²

Activity	Metabolic rates [M]	
Reclining	46 W/m^2	0.8 Met
Seated relaxed	58 W/m^2	1.0 Met
Clock and watch repairer	65 W/m^2	1.1 Met
Standing relaxed	70 W/m^2	1.2 Met
Sedentary activity (office, dwelling, school, laboratory)	70 W/m^2	1.2 Met
Car driving	80 W/m^2	1.4 Met
Graphic profession - Book Binder	85 W/m^2	1.5 Met
Standing, light activity (shopping, laboratory, light industry)	93 W/m^2	1.6 Met
Teacher	95 W/m^2	1.6 Met
Domestic work - shaving, washing and dressing	100 W/m^2	1.7 Met
Walking on the level, 2 km/h	110 W/m^2	1.9 Met
Standing, medium activity (shop assistant, domestic work)	116 W/m^2	2.0 Met
Building industry - brick laying (block of 15.3 kg)	125 W/m^2	2.2 Met
Washing dishes standing	145 W/m^2	2,5 Met
Domestic work - raking leaves on the lawn	170 W/m^2	2.9 Met
Domestic work - washing by hand and ironing (120-220 W/m^2)	170 W/m^2	2.9 Met
Iron and steel - ramming the mould with a pneumatic hammer	175 W/m^2	3.0 Met
Building industry - forming the mould	180 W/m^2	3.1 Met
Walking on the level, 5 km/h	200 W/m^2	3.4 Met
Forestry - cutting across the grain with a one-man power saw	205 W/m^2	3.5 Met
Agriculture - ploughing with a team of horses	235 W/m^2	4.0 Met
Building industry - loading a wheelbarrow with stones and mortar	275 W/m^2	4.7 Met
Sports - ice skating, 18 km/h	360 W/m^2	6.2 Met
Agriculture - digging with a spade (24 lifts/min.)	380 W/m^2	6.5 Met
Sports - skiing on level, good snow, 9 km/h	405 W/m^2	7.0 Met
Forestry - working with an axe (weight 2 kg. 33 blows/min.)	500 W/m^2	8.6 Met
Sports - running, 15 km/h	550 W/m^2	9.5 Met

References:

1. INNOVA, *Thermal comfort*. 2004, AirTech Instruments.

Appendix 2:
Clo values for different clothes garments

Appendix 2: Clothing value for garments [1]:

Table 1: Thermal insulation values for typical garments

Note:
1 clo = 0.155 m^2 °C/W

Garment description		I_{clu} Clo	I_{clu} m^2 °C/W
Jacket	Vest	0.13	0.020
	Light summer jacket	0.25	0.039
	Jacket	0.35	0.054
	Smock	0.30	0.047
Coats and overjackets and overtrousers	Coat	0.60	0.093
	Down jacket	0.55	0.085
	Parka	0.70	0.109
	Overalls multi-component	0.52	0.081
Sundries	Socks	0.02	0.003
	Thick, ankle socks	0.05	0.008
	Thick, long socks	0.10	0.016
	Slippers, quilted fleece	0.03	0.005
	Shoes (thin soled)	0.02	0.003
	Shoes (thick soled)	0.04	0.006
	Boots	0.10	0.016
	Gloves	0.05	0.008
Skirts, dresses	Light skirt, 15 cm. above knee	0.10	0.016
	Light skirt, 15 cm. below knee	0.18	0.028
	Heavy skirt, knee-length	0.25	0.039
	Light dress, sleeveless	0.25	0.039
	Winter dress long sleeves	0.40	0.062
Sleepwear	Long sleeve, long gown	0.30	0.047
	Thin strap, short gown	0.15	0.023
	Hospital gown	0.31	0.048
	Long sleeve, long pyjamas	0.50	0.078
	Body sleep with feet	0.72	0.112
	Undershorts	0.10	0.016
Robes	Long sleeve, wrap, long	0.53	0.082
	Long sleeve, wrap, short	0.41	0.064
Chairs	Wooden or metal	0.00	0.000
	Fabric-covered, cushioned, swivel	0.10	0.016
	Armchair	0.20	0.032

Table 2: Thermal insulation values for typical garments

Note:
1 clo = 0.155 m^2 °C/W

Garment description		I_{clu} Clo	I_{clu} m^2 °C/W
Underwear, pants	Pantyhose	0.02	0.003
	Panties	0.03	0.005
	Briefs	0.04	0.006
	Pants 1/2 long legs, wool	0.06	0.009
	Pants long legs	0.10	0.016
Underwear, shirts	Bra	0.01	0.002
	Shirt sleeveless	0.06	0.009
	T-shirt	0.09	0.014
	Shirt with long sleeves	0.12	0.019
	Half-slip, nylon	0.14	0.022
Shirts	Tube top	0.06	0.009
	Short sleeve	0.09	0.029
	Light weight blouse, long sleeves	0.15	0.023
	Light weight, long sleeves	0.20	0.031
	Normal, long sleeves	0.25	0.039
	Flannel shirt, long sleeves	0.30	0.047
	Long sleeves, turtleneck blouse	0.34	0.053
Trousers	Shorts	0.06	0.009
	Walking shorts	0.11	0.017
	Light-weight trousers	0.20	0.031
	Normal trousers	0.25	0.039
	Flannel trousers	0.28	0.043
	Overalls	0.28	0.043
Coveralls	Daily wear, belted	0.49	0.076
	Work	0.50	0.078
Highly-insulating coveralls	Multi-component, filling	1.03	0.160
	Fibre-pelt	1.13	0.175
Sweaters	Sleeveless vest	0.12	0.019
	Thin sweater	0.20	0.031
	Long sleeves, turtleneck (thin)	0.26	0.040
	Sweater	0.28	0.043
	Thick sweater	0.35	0.054
	Long sleeves, turtleneck (thick)	0.37	0.057

References:

1. INNOVA, *Thermal comfort*. 2004, AirTech Instruments.

Appendix 3:
PMV calculating equations

Appendix 3: PMV calculating equations [1]:

The basis of this equation was obtained from the Fanger's experiments.

$$H - 0.31(57.4 - 0.07H - Pa) - 0.42(H-58) - 0.0017M(58.7 - Pa) - 0.0014M(34 - Ta)$$

$$=$$

$$3.9 \times 10\text{-}8fcl \{(Tcl + 273)\ 4 - (Tr + 273)\ 4\}$$

$$+ fcl\ hc\ (Tcl - Ta) \ldots\ldots\text{(Eq. 1)}$$

Where:
Icl = clothing insulation in clothes
fcr = ratio of clothed/nude surface area
H = Metabolic heat production (w/m2)
M = Metabolic free energy production (external work)(w/m2)
Ta = Air temperature (°C)
Tr = Mean radiant temperature (°C)
v = Relative air speed (m/s)
Pa = Vapor pressure of water vapor (mb)
hc = convective transfer coefficient w/m2 K
Tcl =clothing surface temperature given by:
Tcl = 35.7 - 0.0275H + 0.155Iclo {H - 0.31(57.4 - 0.07H - Pa) - 0.42(H - 58) - 0.0017M(58.7 - Pa) - 0.0014M(34 - Ta)}.

Fanger based his method on the assumption that thermal comfort is defined in terms of the physical state of the body rather than that of the environment and that the sensation experienced by a person is a function of the physiological strain imposed on him by the environment. He defined the thermal load according to the heat balance of the human body and comfort expressions of the mean skin temperature and the sweat rate in the following equation:

$$L = (1 / A_{du})(H - E_d - E_{sw} - E_{re} - L_{re} - R - C) \ldots\ldots\ldots\text{(Eq. 2)}$$

Where:
A_{du} Is the body surface area (DuBois area)
H Is the internal heat production in the human body
E_d Is the heat loss by water vapour diffusion through the skin
E_{sw} Is the heat loss by evaporation of sweat from the surface of the skin
E_{re} Is the latent respiration heat loss
L_{re} Is the dry respiration heat loss
R Is the heat loss by radiation from the outer surface of the clothed body
C Is the heat loss by convection from the outer surface of the clothed body

Assuming that thermal sensation is related to thermal load and thermal heat production, he defined his predicted mean vote (PMV) as:

PMV = f (L, H/A*du*) ....(Eq. 3)

Where L is calculated from the previous equation.

He extended the PMV to predict the proportion of any group who will be dissatisfied with the environment rather than predicting the mean value to be expected from the group. This is known as the Predicted Percentage of persons Dissatisfied (PPD).

H - 0.31(57.4 - 0.07H - Pa) - 0.42(H-58) - 0.0017M (58.7 - Pa) - 0.0014M (34 - Ta)

=

3.9 x 10-8fcl {(Tcl + 273) 4 - (Tr + 273) 4} + fcl hc (Tcl - Ta) ....(Eq. 4)

Where:
Icl = clothing insulation in clothes
fcr = ratio of clothed/nude surface area
H = Metabolic heat production (w/m2)
M = Metabolic free energy production (external work)(w/m2)
Ta = Air temperature (°C)
Tr = Mean radiant temperature (°C)
v = Relative air speed (m/s)
Pa = Vapor pressure of water vapor (mb)
hc = convective transfer coefficient w/m2 K
Tcl =clothing surface temperature given by:
Tcl = 35.7 - 0.0275H + 0.155Iclo {H - 0.31(57.4 - 0.07H - Pa) - 0.42(H - 58) - 0.0017M(58.7 - Pa) - 0.0014M(34 - Ta)}.

References:

1. Gado, T., *A parametric analysis of thermal comfort and cooling in walk-up housing blocks in the Arab Republic of Egypt*, in *Welsh School of Architecture* 2001, University of Wales Cardiff.

Appendix 4:
Description of the case studies of the research

Case study-1 - Dahrot 3

Location	Dahrot village, Maghagha town	
Prototype	T12 - a	
No., of floors	Five	
Components	Twelve classrooms in addition to administrative spaces, services and activities spaces. With attached nursery in the ground floor (refer to the drawings of T12-a prototype)	
Classroom's density		35 student/class
Description		This school is located in a rural context, in the heart of the village. The cultivated land surrounds the school from two sides.
Surroundings	North	Preparatory school with 12 m height
	East	Playground
	South	Residential buildings and cultivated land

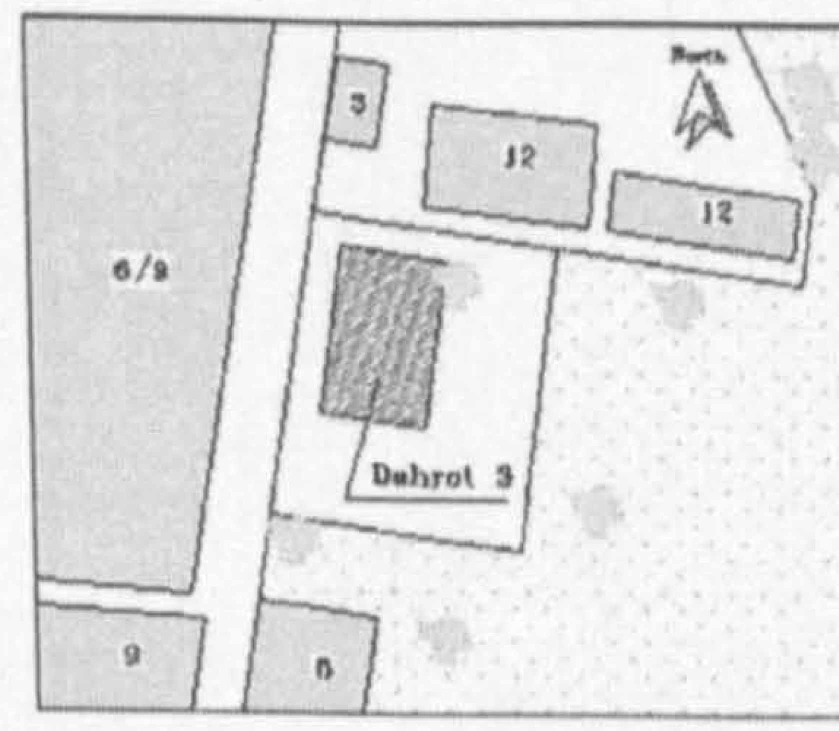


Figure -1: Master plans of case study-1

Figure 2: External view to case study-1 from the main street

Figure 3: The eastern façade of case study-1

Figure 4: The main corridor in a typical floor in case study-1

Case study-2 - Dahrot 4

Location	Dahrot village, Maghagha town	
Prototype	T12 - a	
No., of floors	Five	
Components	Twelve classrooms in addition to administrative spaces, services and activities spaces. In addition to an attached nursery in the ground floor (refer to the drawings of T18 prototype)	
Classroom's density		35 student/class
Description		The school is located in a rural context in the outskirts of the village. It is surrounded by the cultivated land from all its directions.
Surroundings	North	Preparatory school with 12 m height
	East	Playground
	South	Residential buildings and cultivated land
	West	Bumpy road (5 m)

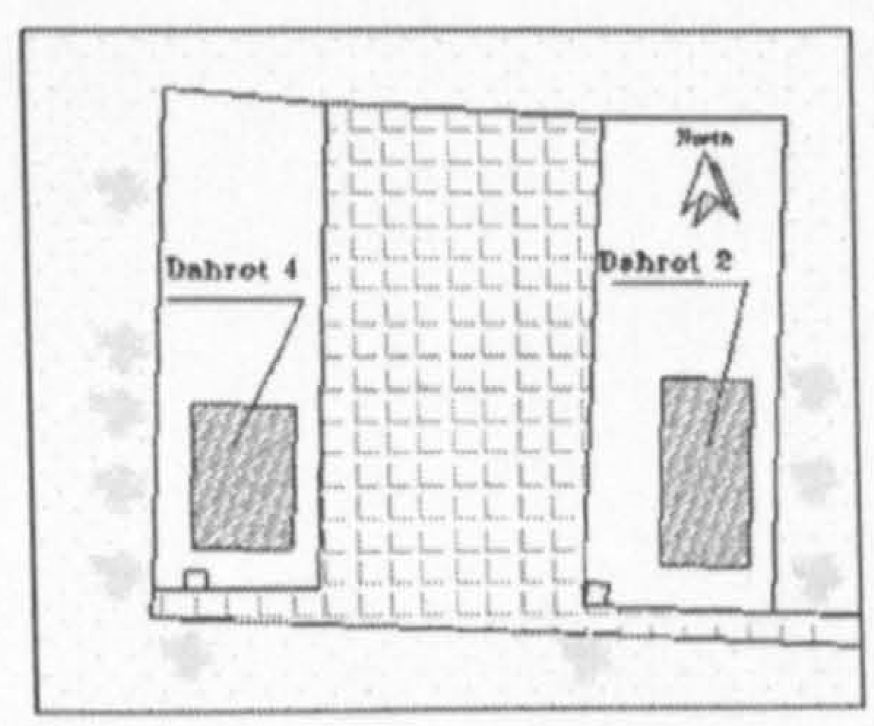


Figure 5: Master plans of case study-2 and case study-3

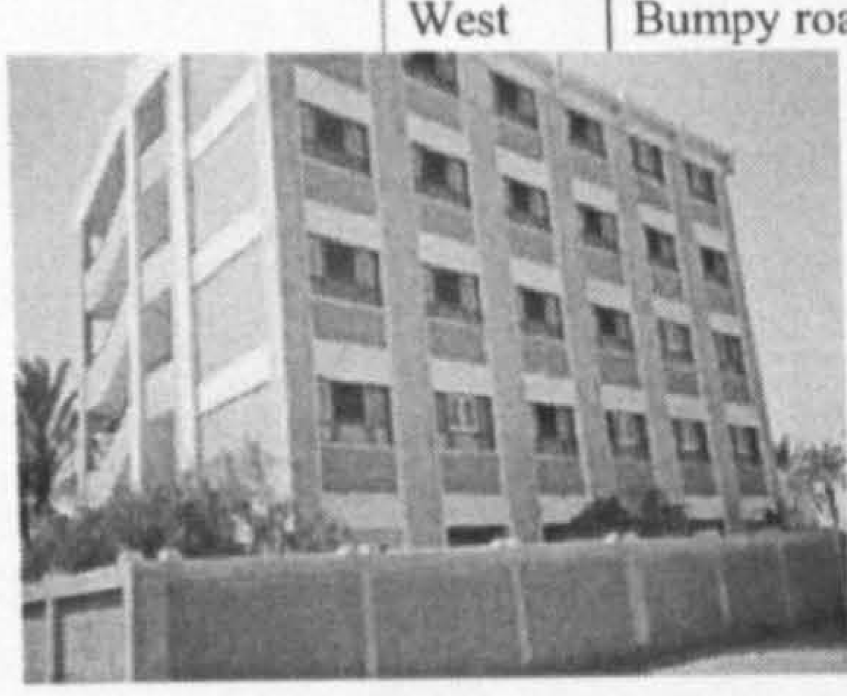


Figure 6: The main façade of case study-2

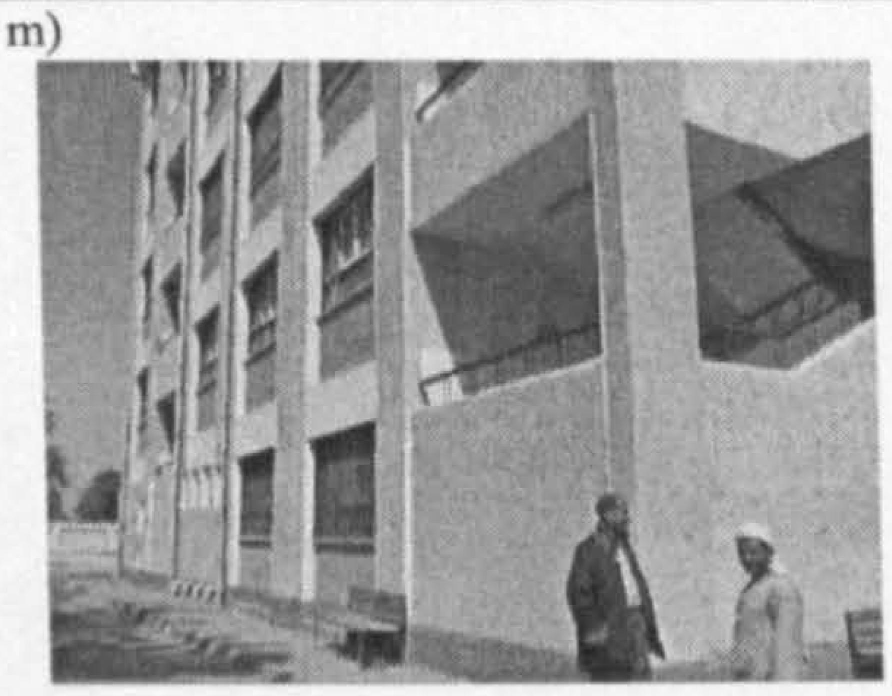


Figure 7: The western façade of case study-2

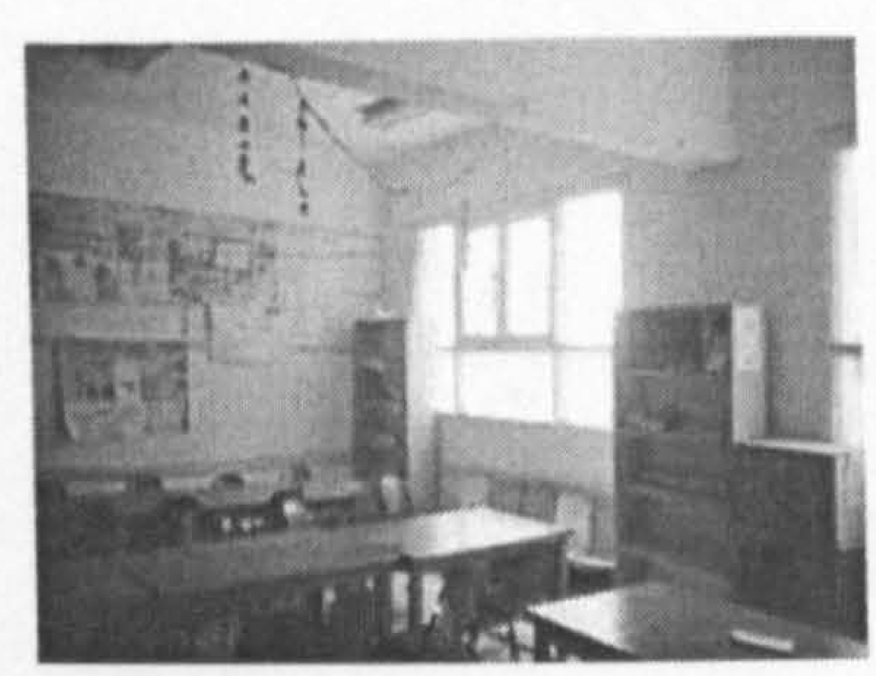


Figure 8: Interior view inside the library of case study-2

Case study-3 - Dahrot 2

Location	Dahrot village, Maghagha town	
Prototype	T18	
No., of floors	Five	
Components	Eighteen classrooms in addition to administrative spaces, services and activities spaces. With attached nursery in the ground floor (refer to the drawings of T18 prototype)	
Classroom's density		35 student/class
Description		The school is located in a rural context in the outskirts of the village. It is surrounded by the cultivated land from all its directions.
Surroundings	North	Playground
	East	Cultivated land
	South	Bumpy road (3 m)

Figure 9: External view of case study-2 and case study-3

Figure 10: External view of case study-3

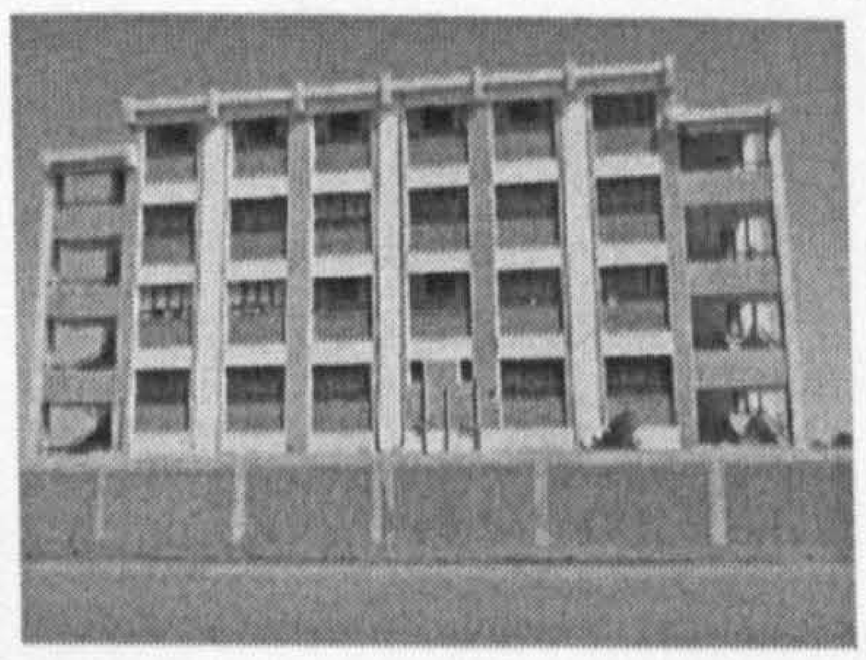


Figure 11: The western façade of case study-3

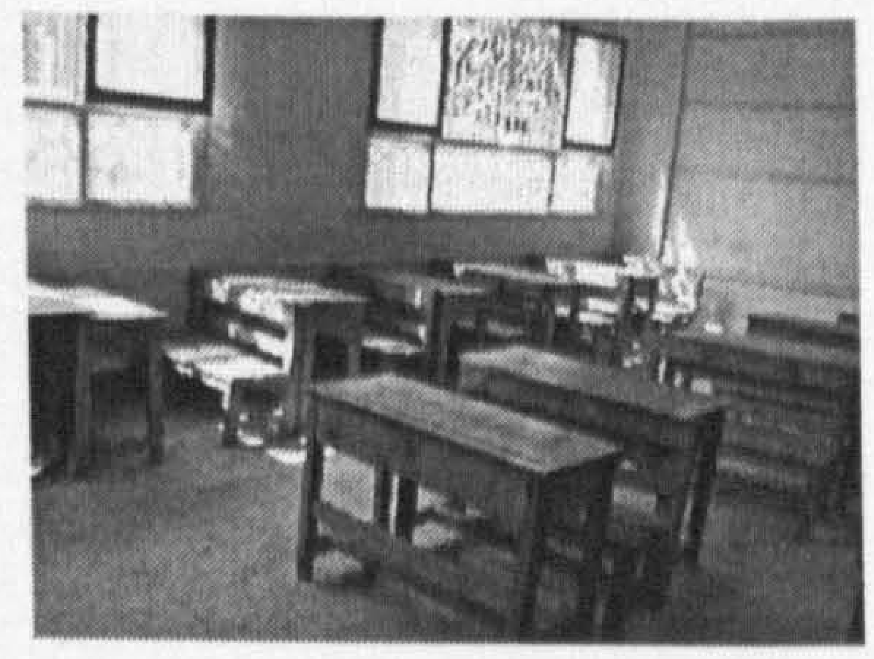


Figure 12: Internal view inside one classroom on the western façade during the break time

Case study-4 - Khaled ebn al-Waled

Location	Dahrot village, Maghagha town	
Prototype	T18	
No., of floors	Five	
Components	Eighteen classrooms in addition to administrative spaces, services and activities spaces. With attached nursery in the ground floor (refer to the drawings of T18 prototype)	
Classroom's density		45 student/class
Description		This school is located in a rural context, in the heart of the village. The housing buildings (1-3 stories) surround the school from all its directions.
Surroundings	North	Housing buildings
	East	The school playground
	South	Bumpy road (3 m)
	West	Bumpy road (3 m)

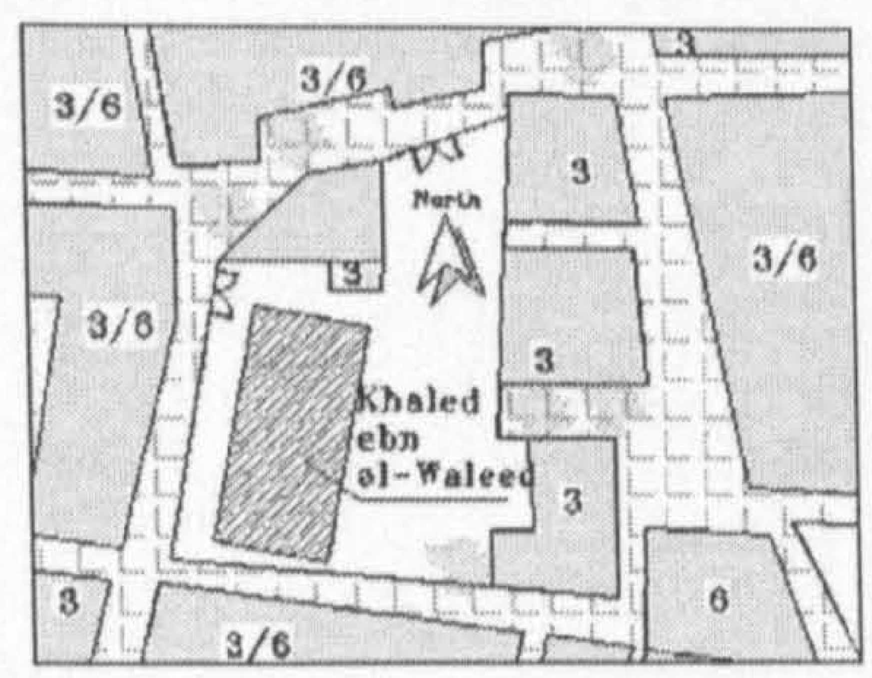


Figure 13: The master plan of case study-4

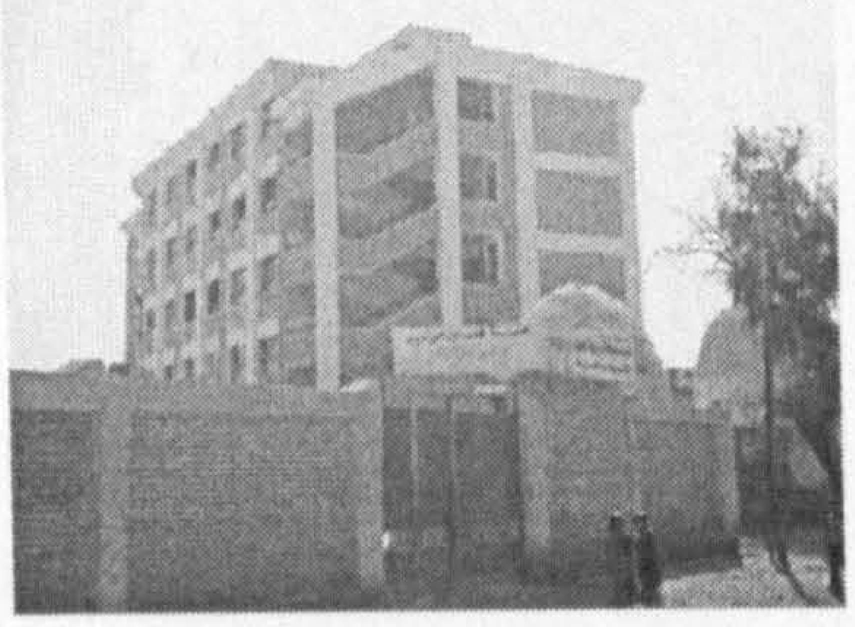


Figure 14: External view of case study-4 from the southern street

Figure 15: The eastern façade of case study-4

Figure 16: External view of case study-4 from the western street

Case study-5 - al-Gharabawe

Location	Al-Gharabawe village, Bani-Mazar town	
Prototype	T6-a	
No., of floors	Five	
Components	Six classrooms in addition to administrative spaces, services and activities spaces. With attached nursery in the ground floor	
Classroom's density		42 student/class
Description		This school is located in a rural context, beside the main traffic road. The housing buildings (1-3 stories) surround the school from all its directions.
Surroundings	North	Housing buildings
	East	The main road (Highway)
	South	Bumpy road (3 m)
	West	Bumpy road (3 m)

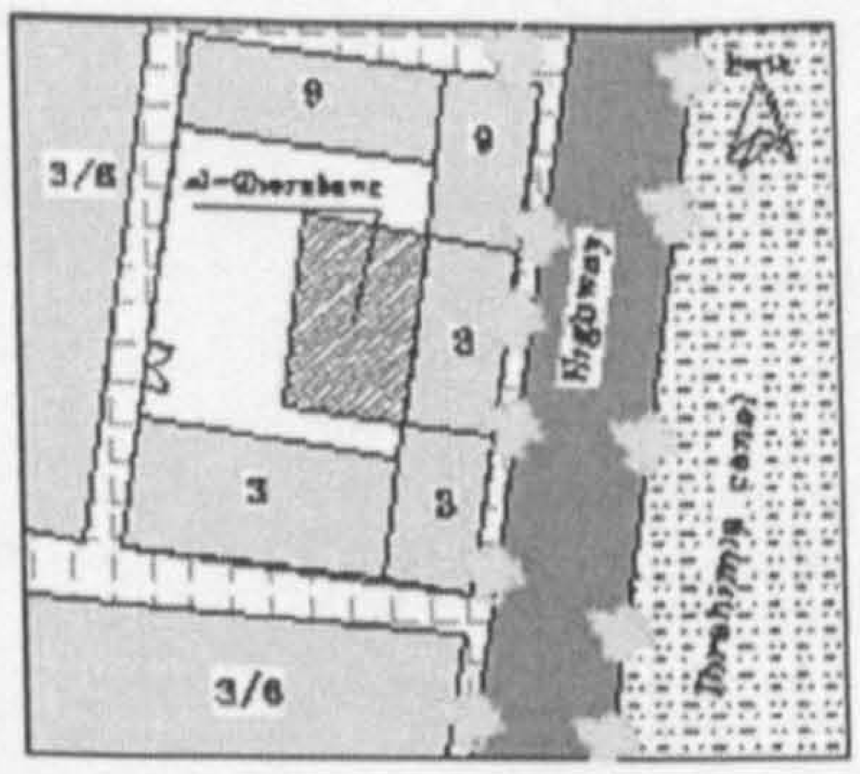


Figure 17: The master plan of case study-5

Figure 18: External view of case study-5 from the main road

Figure 19: The eastern façade of case study-5

Figure 20: A picture inside the corridor of a typical floor of case stuy-5

Case study-6 - Abnaa al-Thora

Location	Bani-Mazar city	
Prototype	T18	
No., of floors	Five	
Components	18 classrooms and administrative spaces, with external WCs and attached nursery in the ground floor (refer to T18 prototype – but the WCs areas are used in this school as additional classrooms)	
Classroom's density		45 student/class
Description		This school is located in an urban context, near to the main road (the high way) in a very crowded area. The housing buildings (1-3 stories) surround the school from two sides and two parking areas from the other two sides.
Surroundings	North	Sub-main street
	East	Parking area
	South	Bumpy road (3 m)

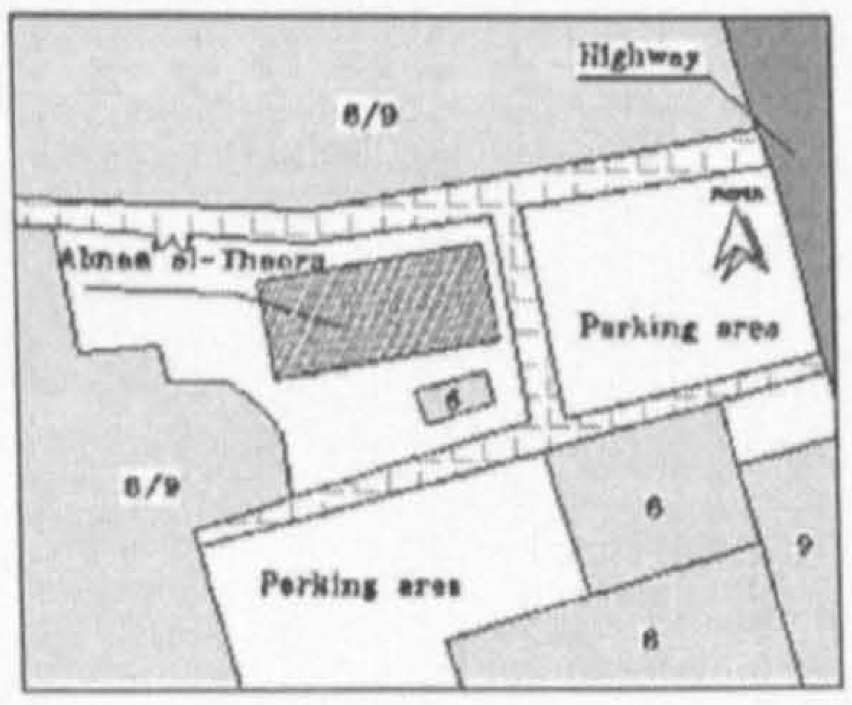


Figure 21: Master plan of case study-6

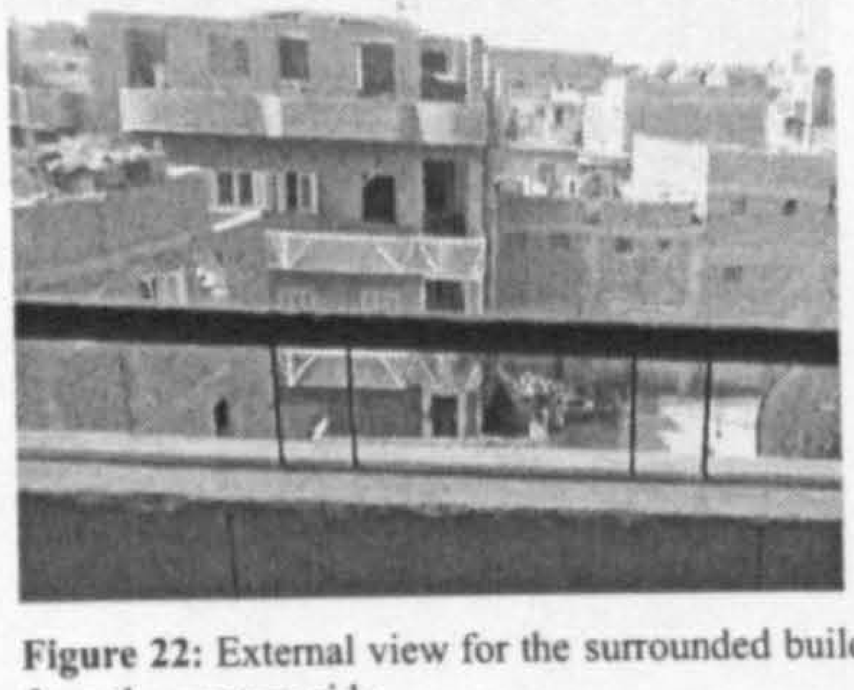


Figure 22: External view for the surrounded buildings from the western side

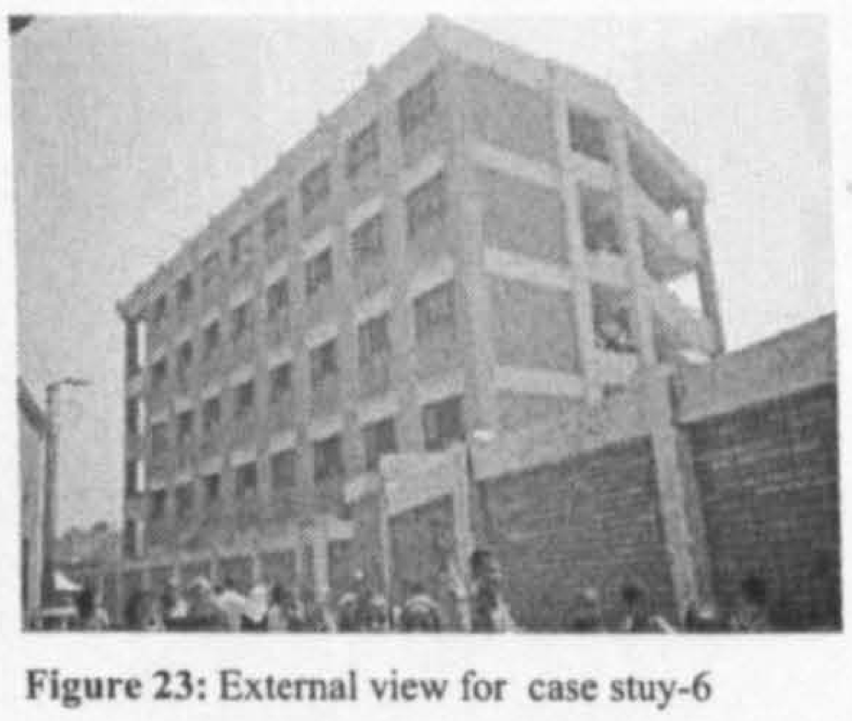


Figure 23: External view for case stuy-6

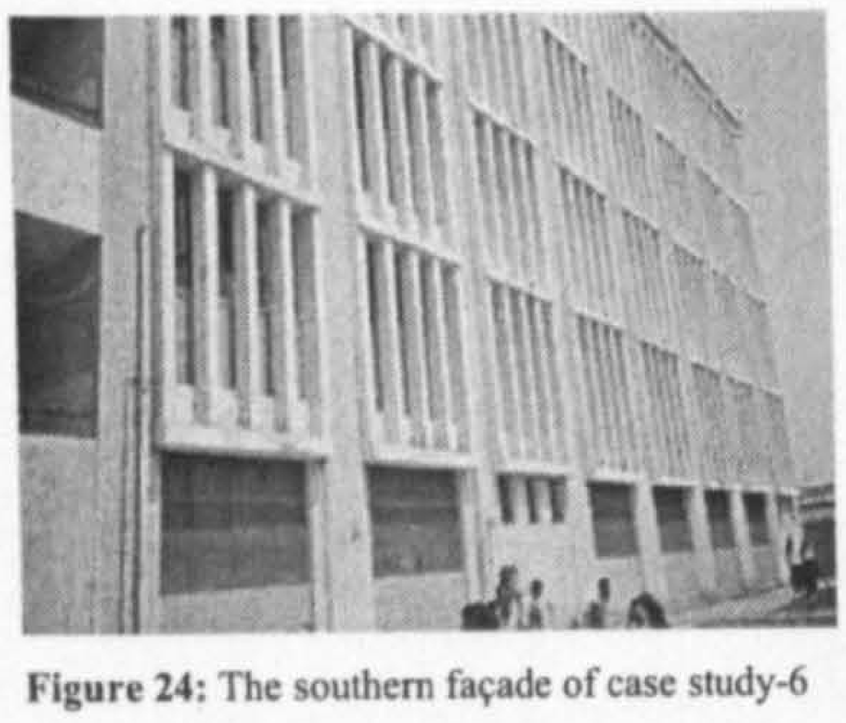


Figure 24: The southern façade of case study-6

Case study-7 - al-Oroba

Location	Matay city	
Prototype	T6-b	
No., of floors	Five	
Components	Six classrooms in addition to using the corridors as another five classrooms with external WCs.	
Classroom's density		58 student/class
Description		This school is located in an urban context, in a very crowded area near to the main road (high way).
Surroundings	North	Sub-main street (8 m)
	East	Sub-main street (4 m)
	South	Another school buildings
	West	Play ground

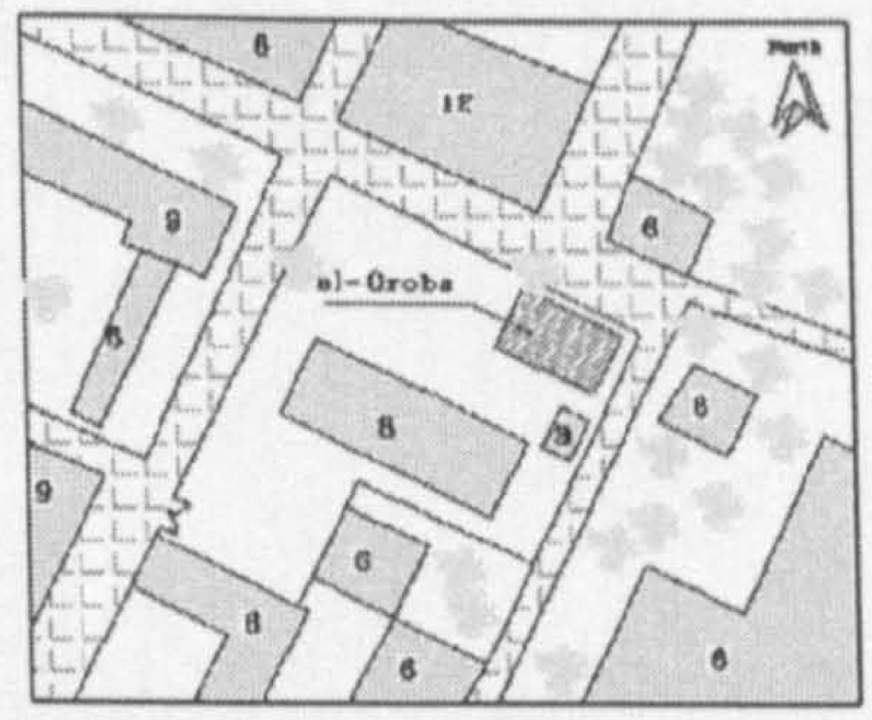


Figure 25: Master plan of case study-7

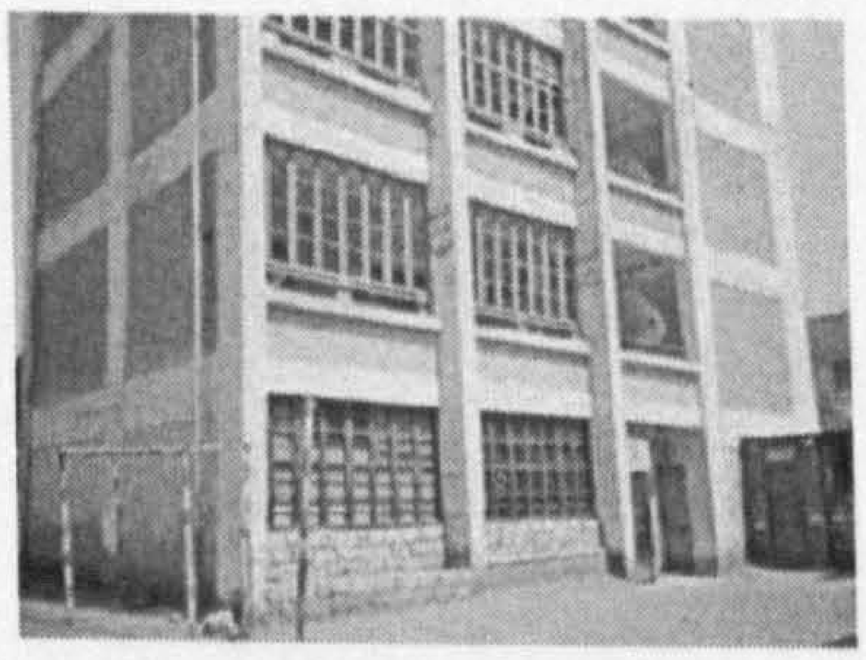


Figure 26: External view showing the use of the corridor as classrooms

Figure 27: External view for case sudy-7 from the street

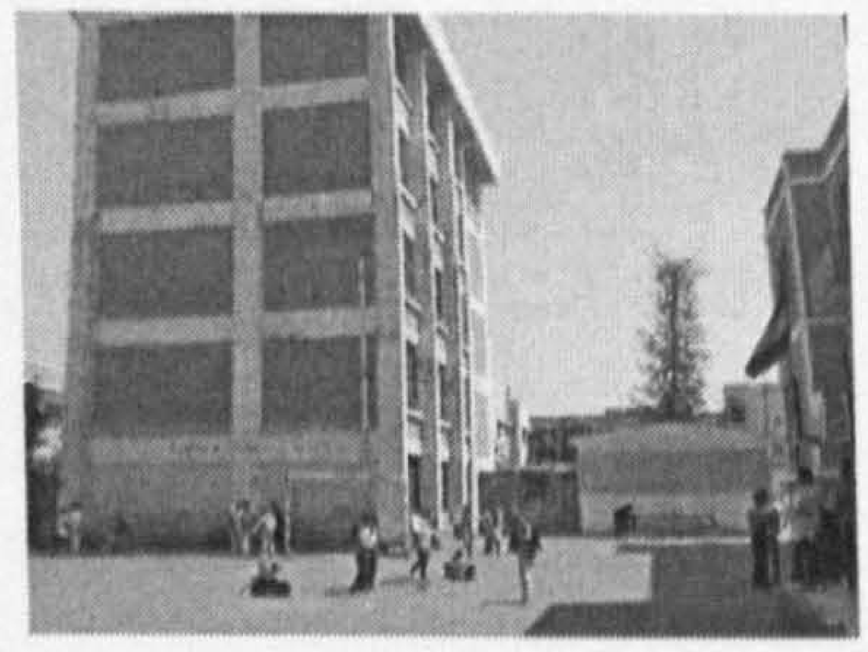


Figure 28: External view of case study-7 from the playground

Case stud-8 - al-Abasia

Location	Al-Abasia village - Matay city	
Prototype	T18	
No., of floors	Five	
Components	Eighteen classrooms in addition to administrative spaces, services and activities spaces with external with attached nursery in the ground floor (refer to the drawings of T18 prototype)	
Classroom's density		45 student/class
Description		This school is located in a rural context, in the heart of the village. The housing buildings (1-3 stories) surround the school from all its directions except the east side which is a cultivated land.
Surroundings	North	Playground
	East	Main street
	South	Cultivated land

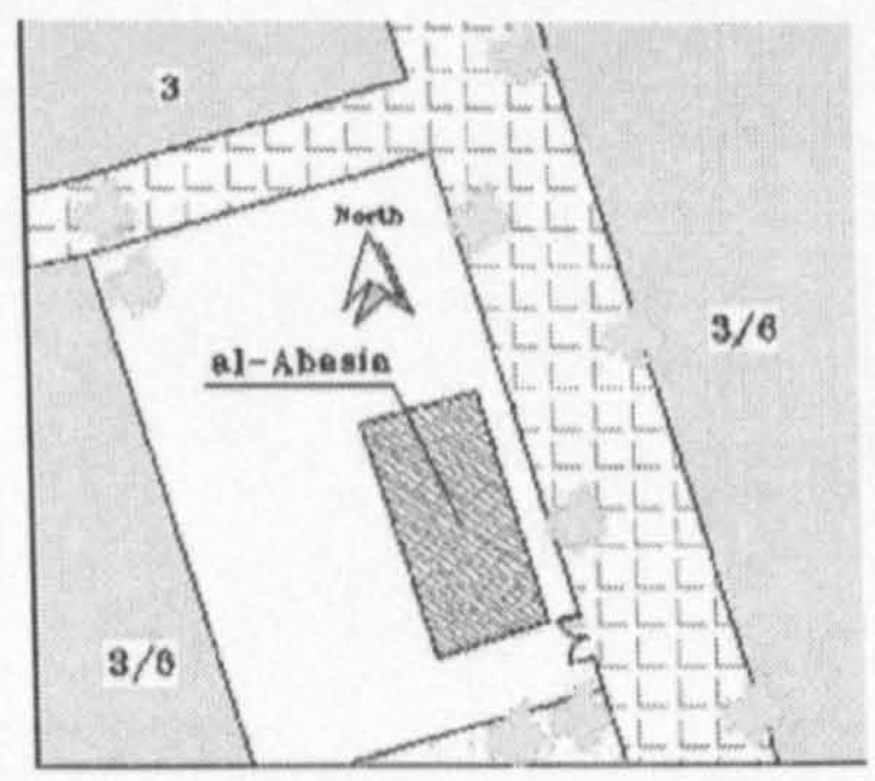


Figure 29: Master plan of case study-8

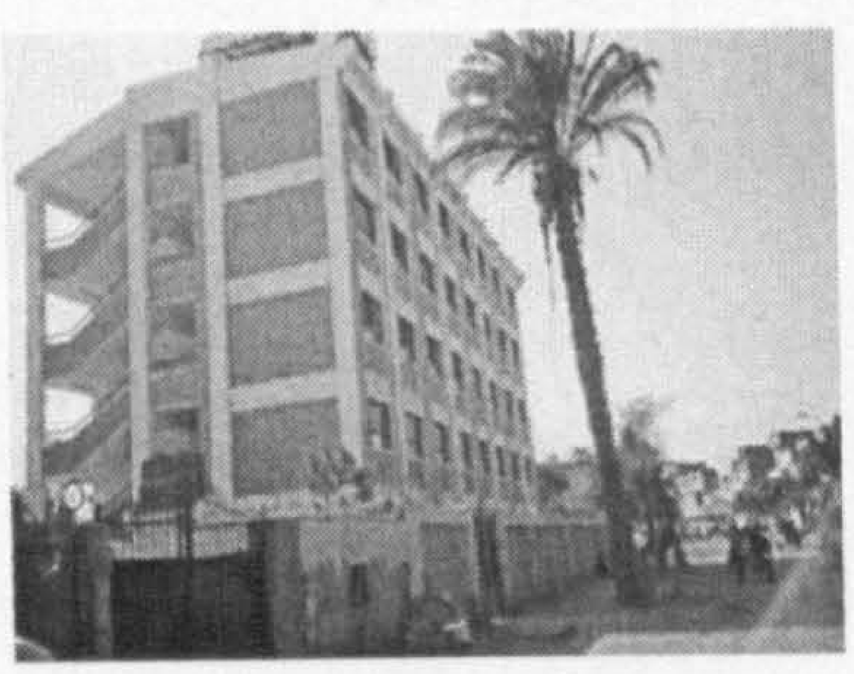


Figure 30: External view of case study-8

Figure 31: The main façade of case study-8

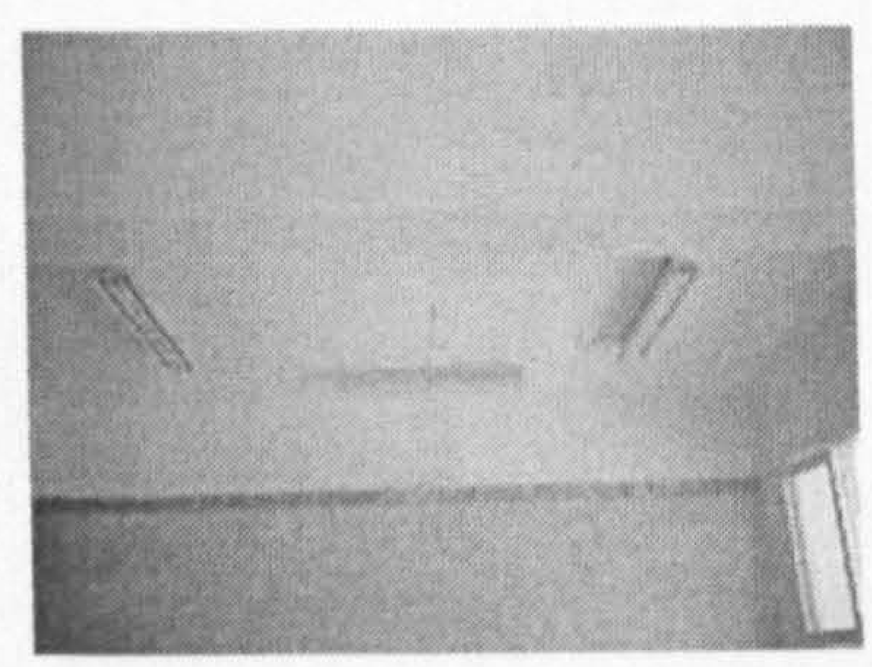


Figure 32: A picture inside one of the classrooms, shows the distribution of lighting

Case study-9 - al-Tawfekia

Location	Al-Tawfekia village- Samalout town	
Prototype	T12-b	
No., of floors	Four	
Components	Twelve classrooms in addition to administrative spaces, services and activities spaces with attached nursery in the ground floor and external WCs building	
Classroom's density		45 student/class
Description		This school is located in rural context, in the outskirts of the village. The cultivated land surrounds the school from two sides. The school consists of two buildings forming together L form.
Surroundings	North	Main street (12 m)
	East	Cultivated land
	South	Cultivated land
	West	Housing buildings (1-2 stories)

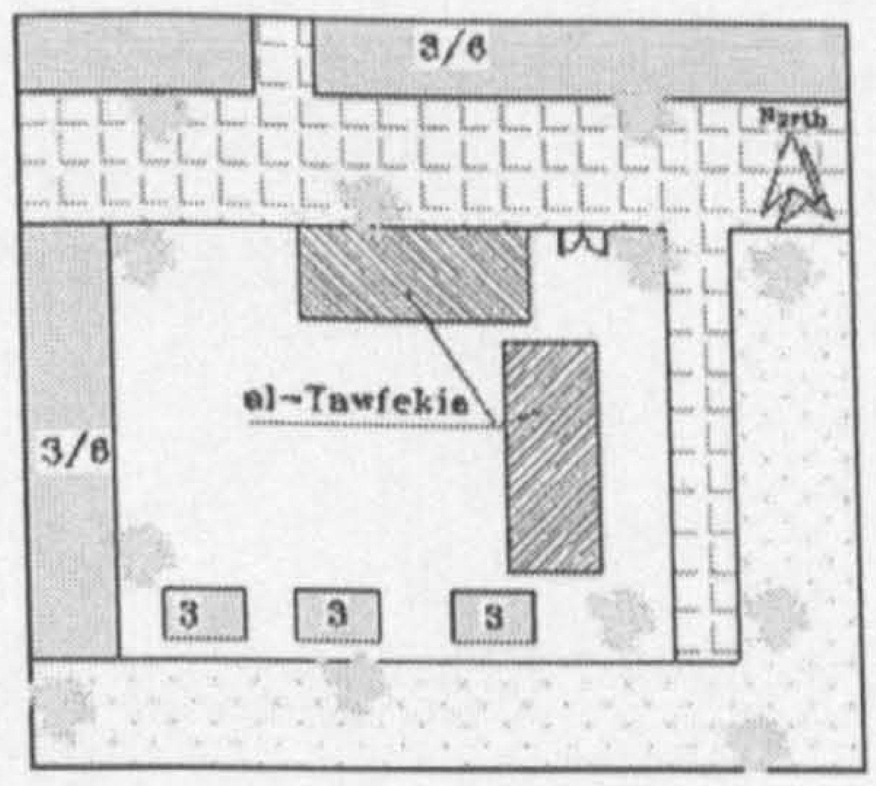


Figure 33: Master plan of case study-9

Figure 34: External view for case study-9 from the play ground

Figure 35: External view for case study-9 from the main street

Case study-10 - Abo Sedhm

Location	Abo Sedhm village- Samalout town	
Prototype	T18	
No., of floors	Five	
Components	Eighteen classrooms in addition to administrative spaces, services and activities spaces. With attached nursery in the ground floor (refer to the drawings of T18 prototype)	
Classroom's density		38 student/class
Description		This school is located in rural context, in the outskirts of the village. The cultivated land surrounds the school from all its directions except some houses from the north side.
Surroundings	North	Sub-main street
	East	Main street
	South	Cultivated land
	West	Cultivated land

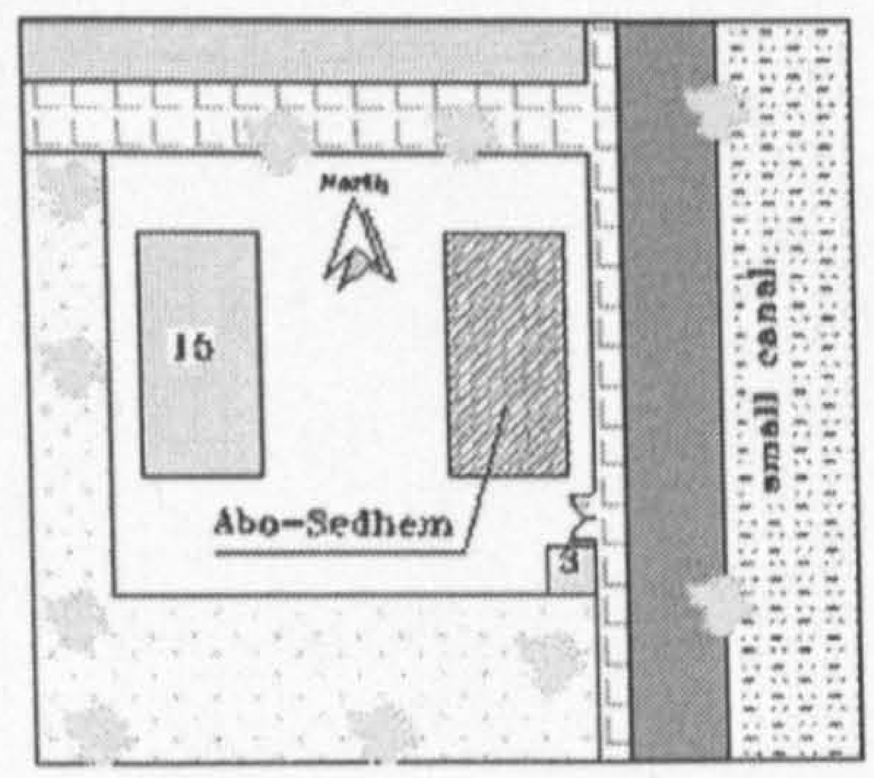


Figure 36: Master plan of case study-10

Figure 37: The main façade of case study-10

Figure 38: The main entrance of case study-10

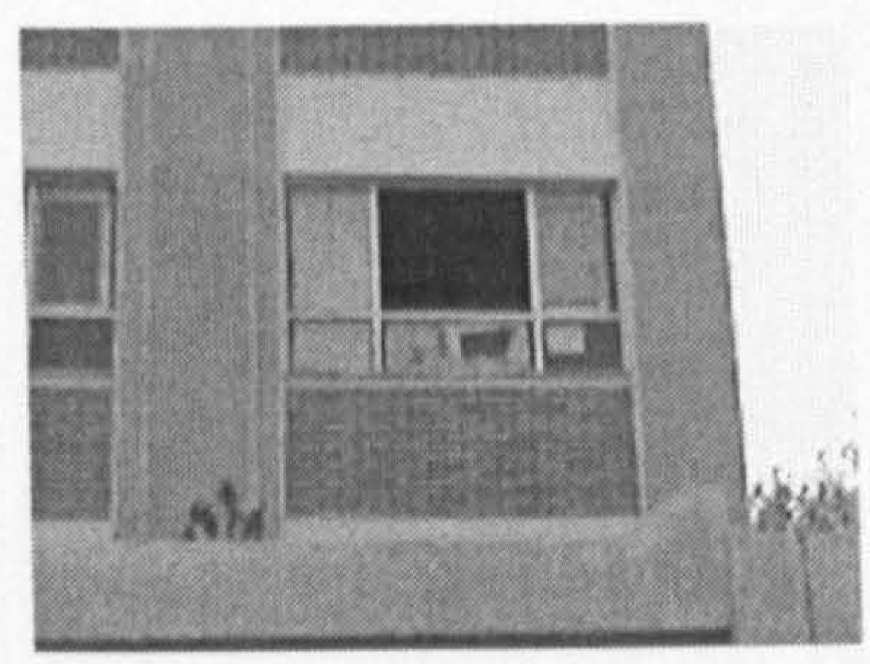


Figure 39: School windows are covered by papers to block the solar access

Case study-11 - Terfa al-Balad

Location	Terfa al-Balad village, Samalout town	
Prototype	T18	
No., of floors	Five	
Components	Eighteen classrooms in addition to administrative spaces, services and activities spaces. With attached nursery in the ground floor (refer to the drawings of T18 prototype)	
Classroom's density		45 student/class
Description		This school is located in a rural context, in the outskirts of the village. The cultivated land surrounds the school almost from all its directions.
Surroundings	North	The school playground
	East	Bumpy road and small canal
	South	Main road

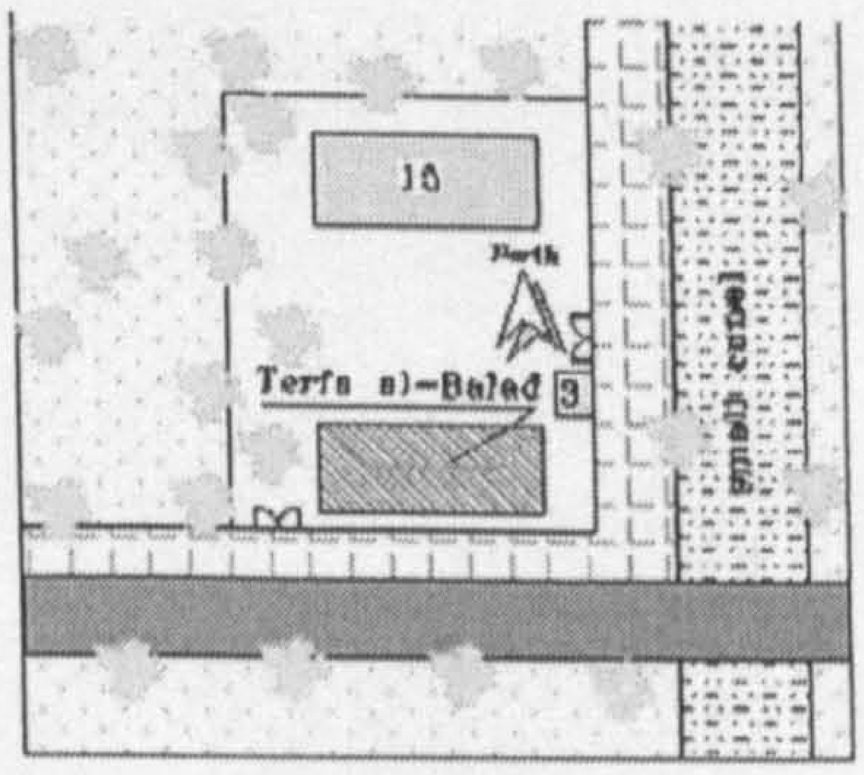


Figure 40: Master plan of case study-11


Figure 41: External view case study-11 from the eastern street

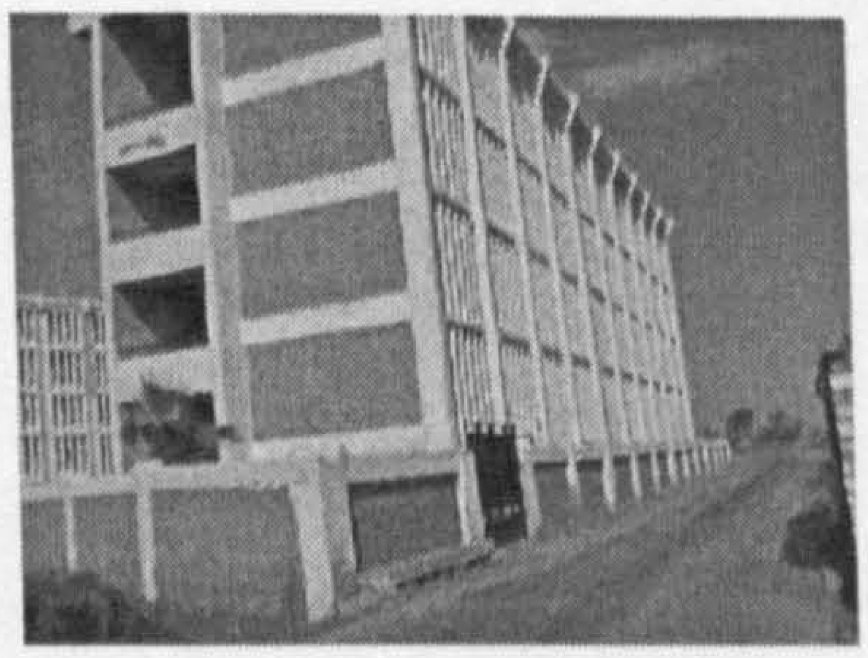


Figure 42: External view of case study-11 from the western direction

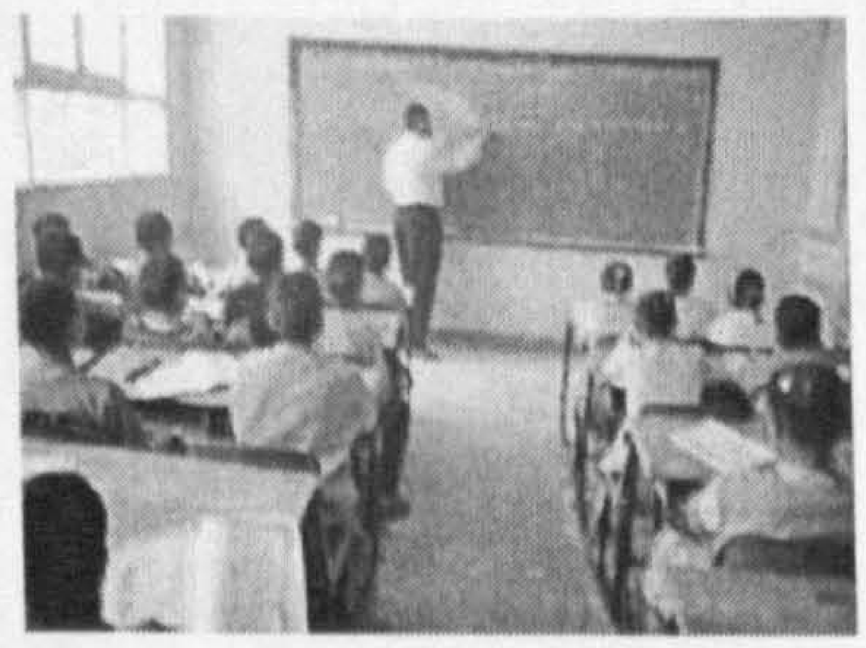


Figure 43: A picture inside one of the classrooms of case study-11

Case study-12 - al-Shaheed

Location	Al-Minya City	
Prototype	T12-b	
No., of floors	Four	
Components	Twelve classrooms in addition to administrative spaces, services and activities spaces in addition to use the corridors as additional classes. (refer to the drawings of T12-b prototype)	
Classroom's density		55 student/class
Description		This school is located in an urban context, in a very crowded area. The housing buildings (1-3 stories) surround the school almost from all its directions.
Surroundings	North	Housing buildings
	East	The school playground
	South	Bumpy road (3 m)

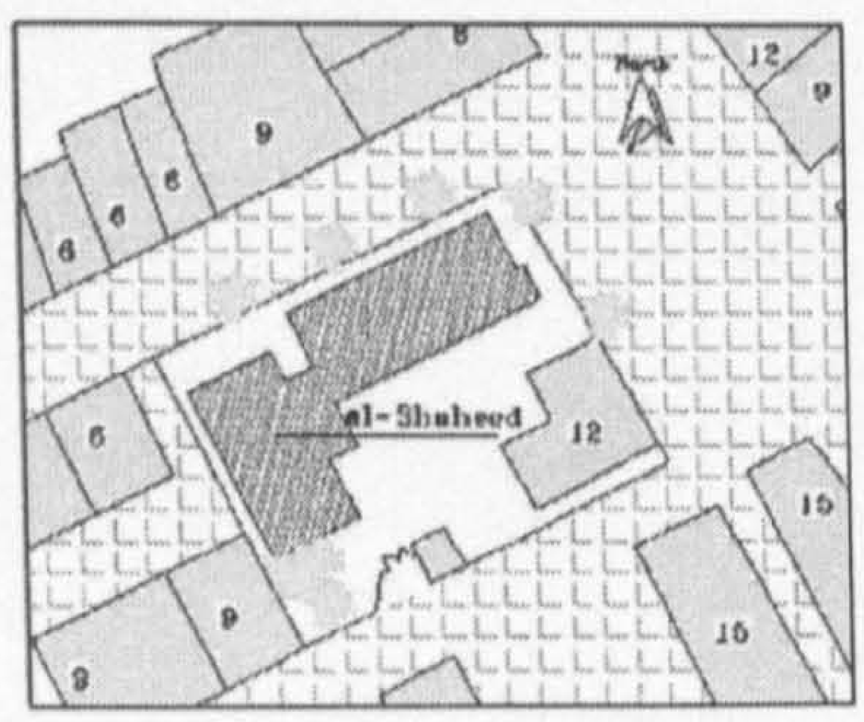


Figure 44: Master plan of case study-12

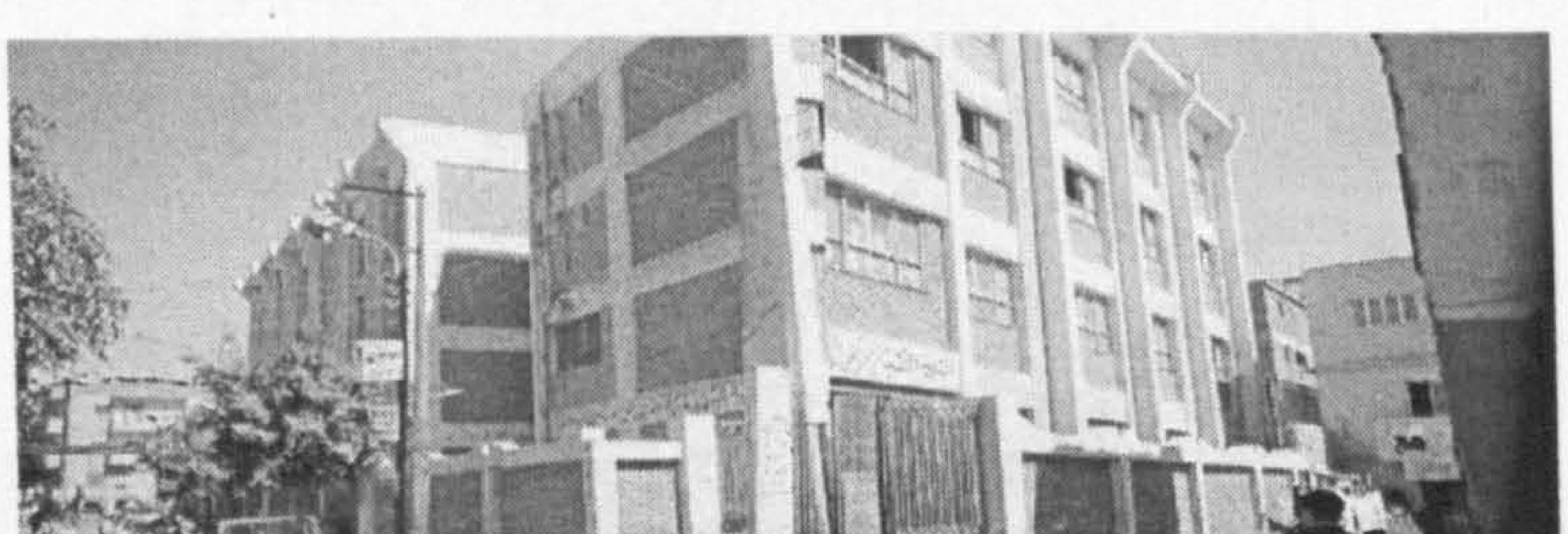


Figure 45: External view of case study-12 from the street


Figure 46: External view of case study-12 from the playground

Case study-13 - Makosa

Location	Makosa village – Al-Minya town			
Prototype	T12-a			
No., of floors	Four			
Components	Twelve classrooms in addition to administrative spaces, services and activities spaces. With attached nursery in the ground floor (refer to the drawings of T12-a prototype)			
Classroom's density	45 student/class			
Description	This school is located in rural context, in the outskirts of the village. The cultivated land surrounds the school from almost all its directions.			
Surroundings	North	Cultivated land	East	The school playground
	South	The village football playground		

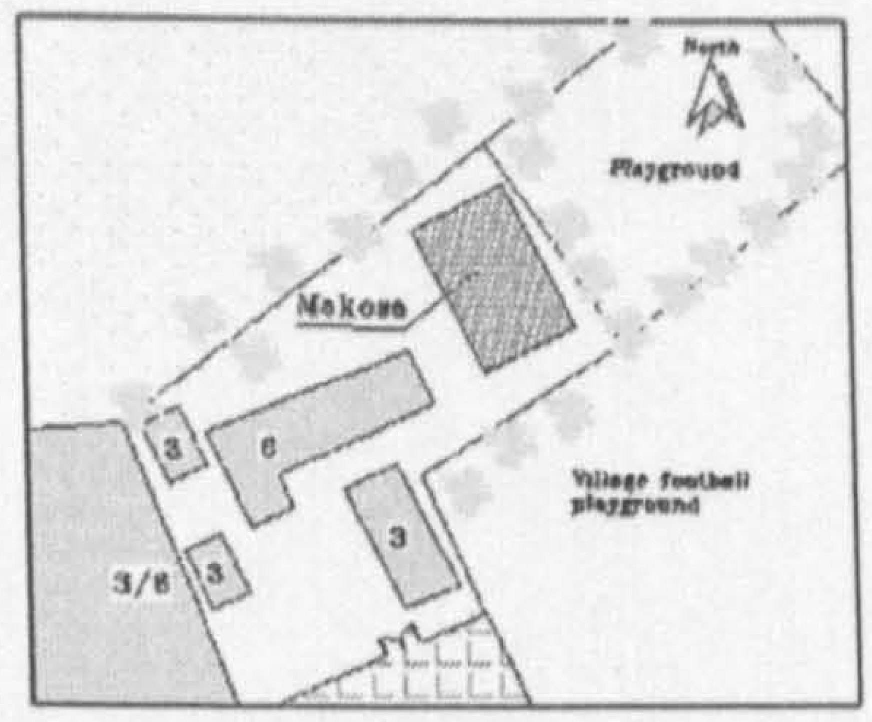


Figure 47: Master plan of case study-13

Figure 48: The surrounding cultivated land for case study-13, captured from the school roof

Figure 49: The main façade of case study-13 with the main entrance

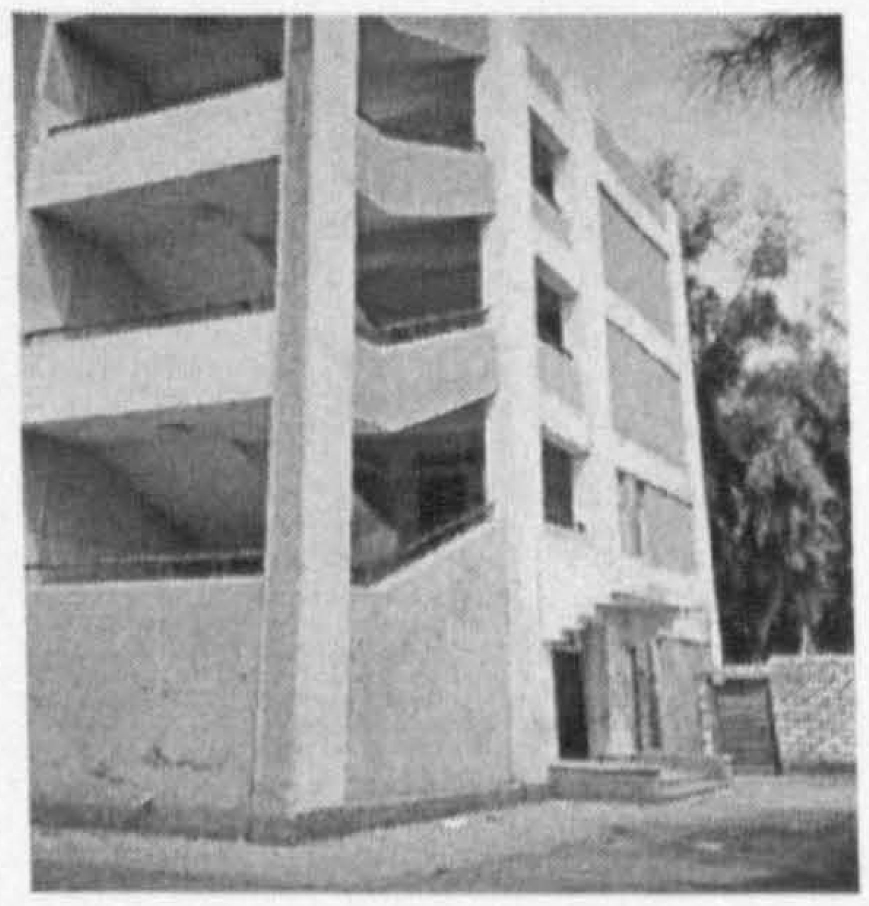


Figure 50: The nursery entrance of case study-13

Case study-14 - Omar ebn al-Khatab

Location	al-Minya City	
Prototype	T6-a	
No., of floors	3	
Components	6 classrooms in the upper two typical floors in addition to; library, water closest for boys and girls, and two small rooms for management in the ground floor	
Classroom's density	56 student/class	
Description	This school is located in an urban context, in the heart of a very crowded area. The housing buildings (1-5 stories) surround the school from all its directions.	
Surroundings	North	Playground
	East	Playground with a 5 story buildings (15 m)
	South	Sub-main street (8 m)
	West	Main street (12 m)

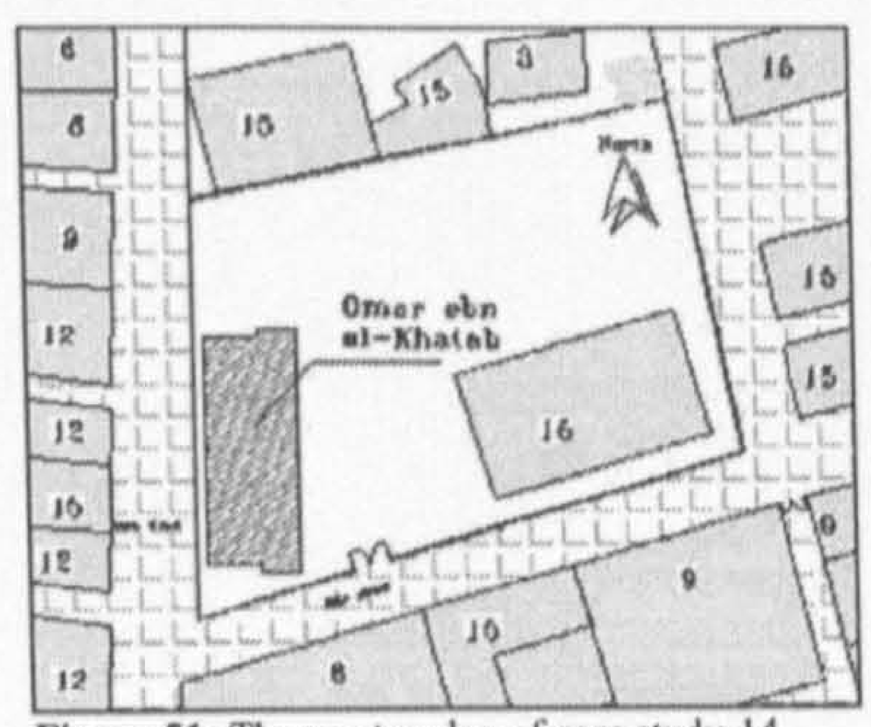


Figure 51: The master plan of case study-14

Figure 52: The eastern façade of case study-14

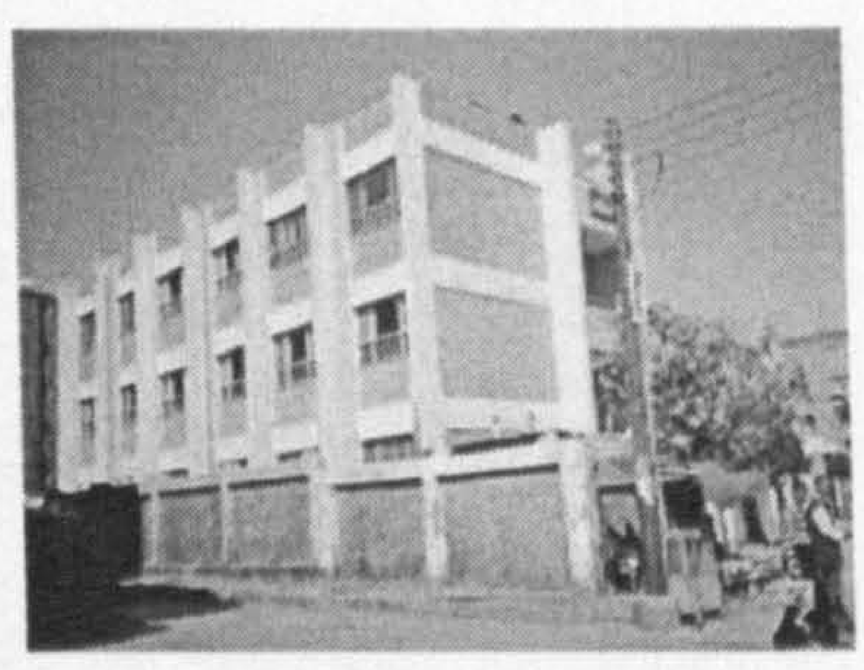


Figure 53: The western façade of case study-14

Figure 54: Interior view inside a typical classroom of case study-14

Case study-15 - Salah al-Din

Location	Abou –Qurqaas city	
Prototype	T6-b	
No., of floors	Three	
Components	Six classrooms without any additional spaces and external WCs. It is an extension for already built school. (refer to the drawings of T6-b prototype)	
Classroom's density		56 student/class
Description		This school is located in an urban context, in a very crowded area. The housing buildings (1-5 stories) surround the school from all its directions.
Surroundings	North	Another school buildings (15m height)
	East	The school playground and the main school
	South	Sub-main street (6)

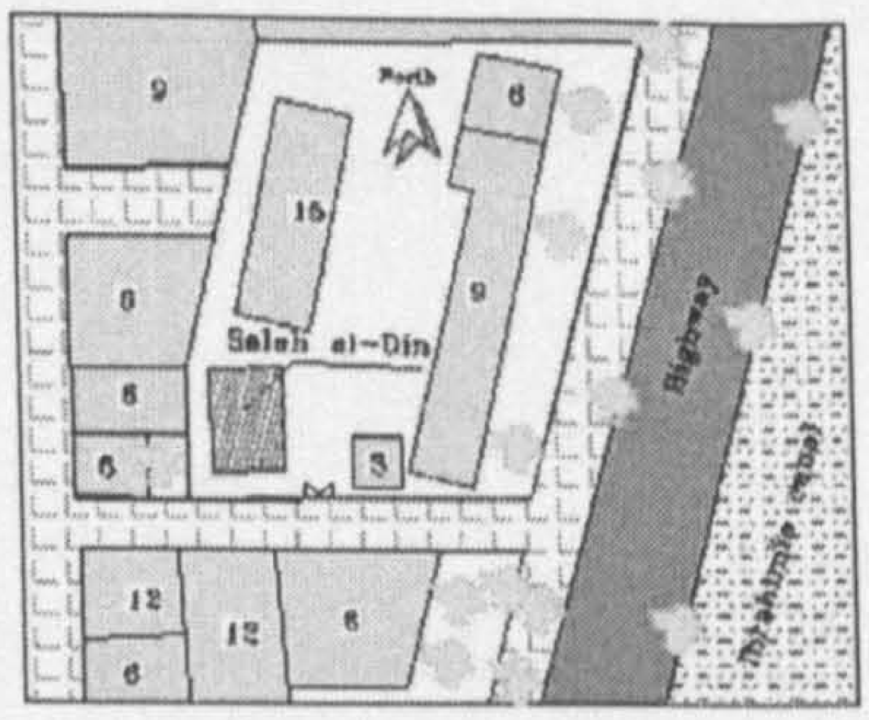


Figure 55: Master plan of case study-15

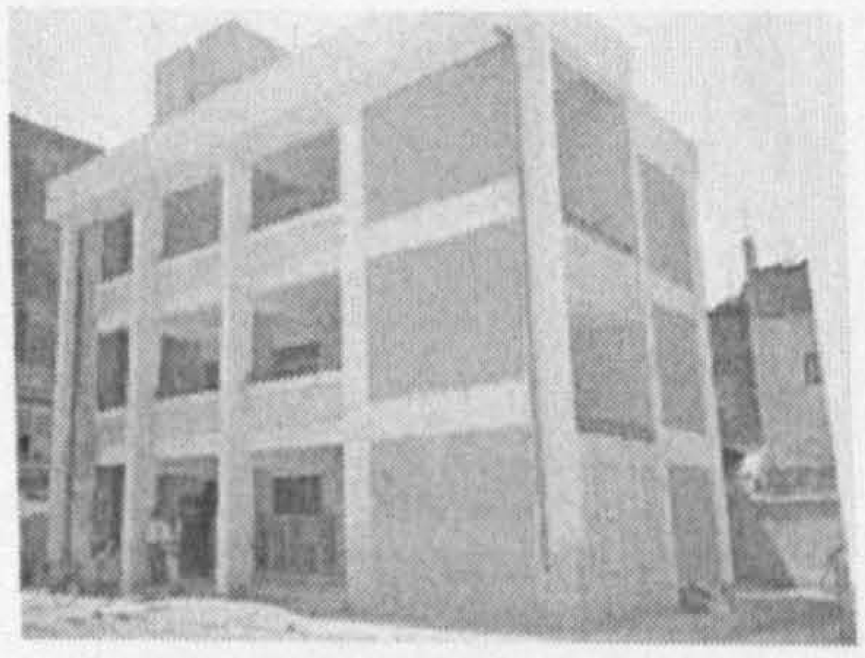


Figure 56: External view of case study-15

Figure 57: Internal view through the corridor of case study-15

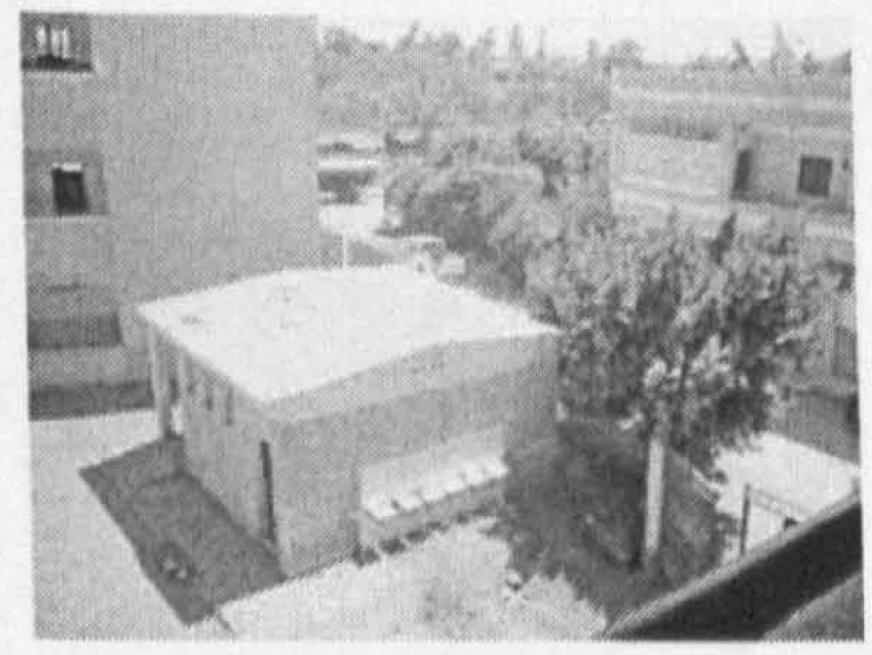


Figure 58: The toilets as a separate building in case study-15

Case study-16 - Monsha'a al-Fekrea

Location	Abou - Qurqaas	
Prototype	T12	
No., of floors	Five	
Components	Twelve classrooms in addition to administrative spaces, services and activities spaces.	
Classroom's density		55 student/class
Description		This school is located in an urban context, in the outskirts of the city.
Surroundings	North	Another school building
	East	The main road (highway)
	South	Bumpy road (12 m)

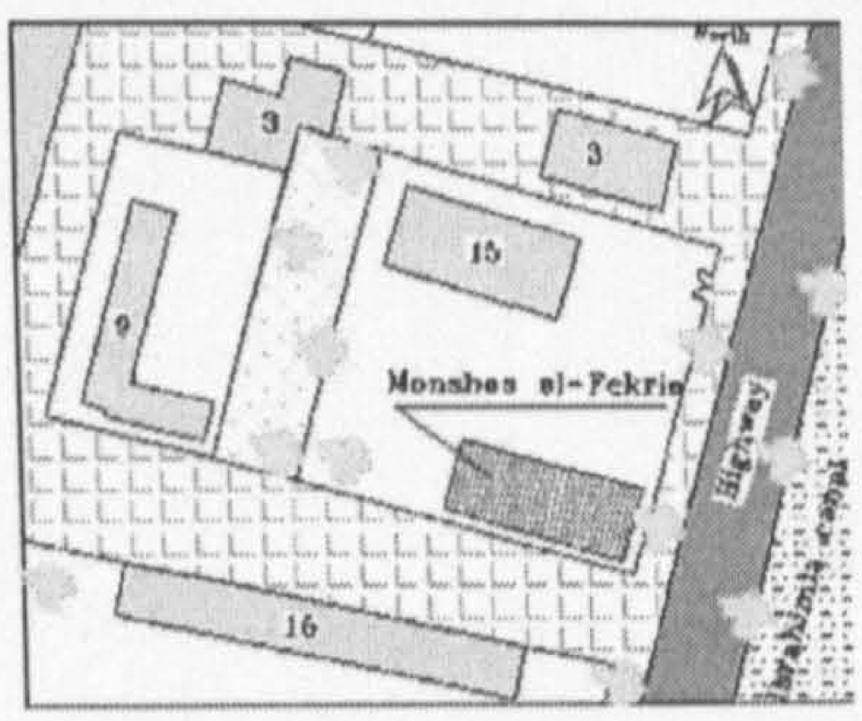


Figure 59: Master plan of case study-16

Figure 60: External view of case study-16

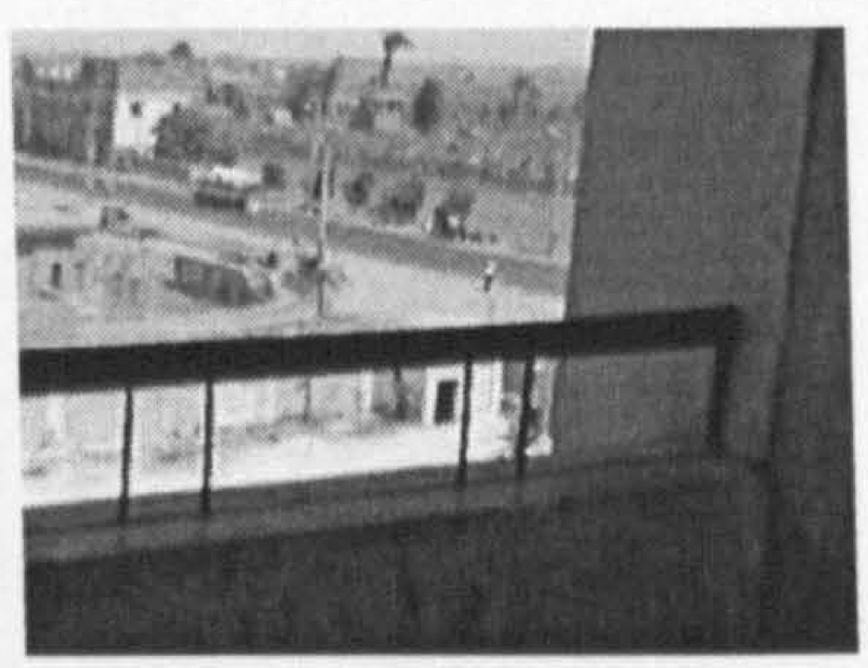


Figure 61: A picture from the school to the outside

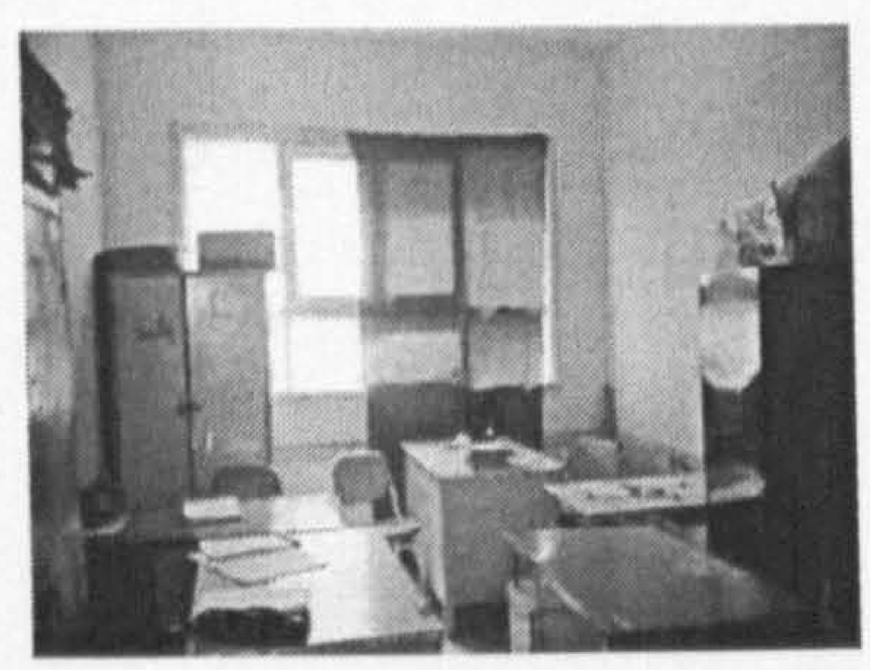


Figure 62: The staff offices in case study-16

Case study-17 - al-Ashmonin

Location	Al-Ashmonin village, Malawi town	
Prototype	T18	
No., of floors	Five	
Components	Eighteen classrooms in addition to administrative spaces, services and activities spaces.	
Classroom's density		38 student/class
Description		This school is located in a rural context, in the outskirts of the village.
Surroundings	North	Another school building
	East	Cultivated land
	South	Cultivated land
	West	Main road

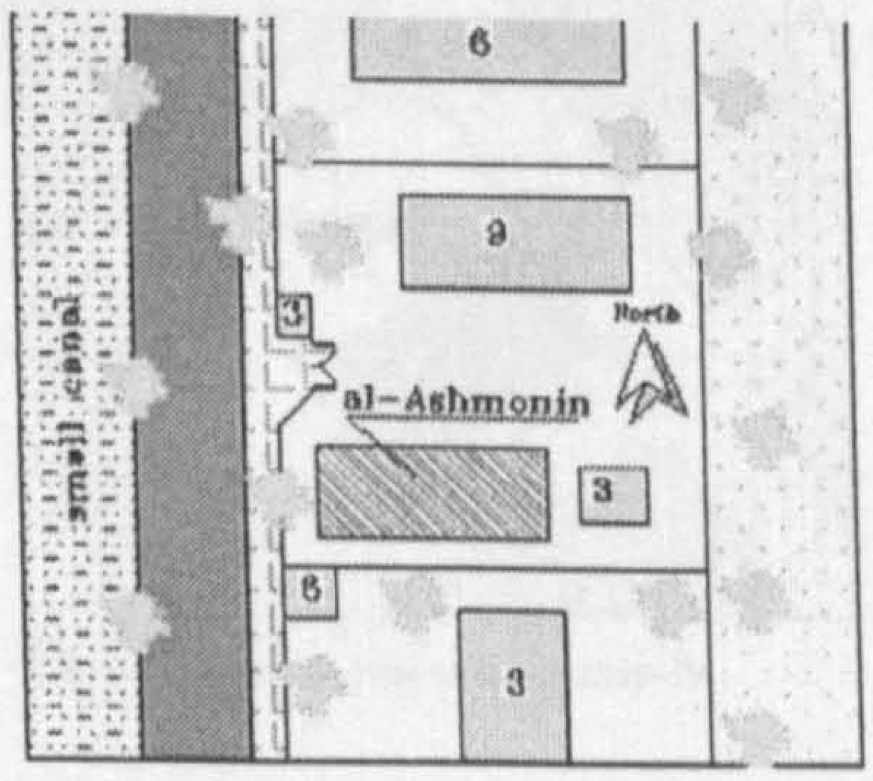


Figure 63: Master plan of case study-17


Figure 64: External view of case study-17

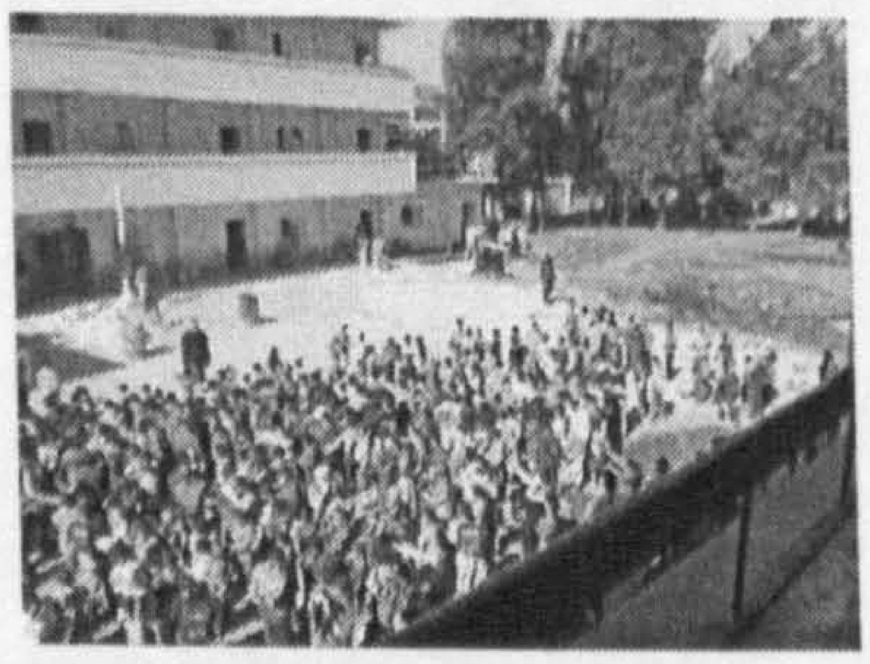


Figure 65: The students stands in the playground of case study-17


Figure 66: The outside toilets in case study-17

Case study-18 - Kolba

Location	Kolba - Malawi	
Prototype	T6-b	
No., of floors	Four	
Components	Six classrooms without any additional spaces and external WCs. It is an extension for already built school. (refer to the drawings of T6-b prototype)	
Classroom's density		45 student/class
Description		This school is located in rural context, in the heart of the village. The housing buildings (1-3 stories) surround the school from three sides and the rest of the school from the fourth side.
Surroundings	North	The playground and the rest of the school buildings
	East	Bumpy road (8 m)
	South	Bumpy road (3 m)

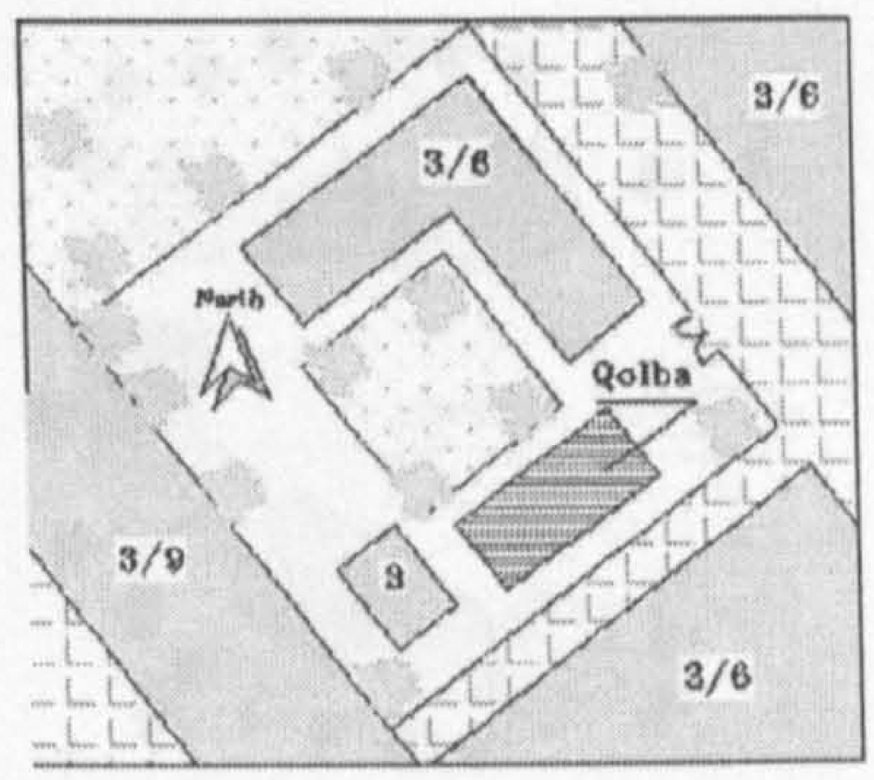


Figure 67: Master plan of case study-18

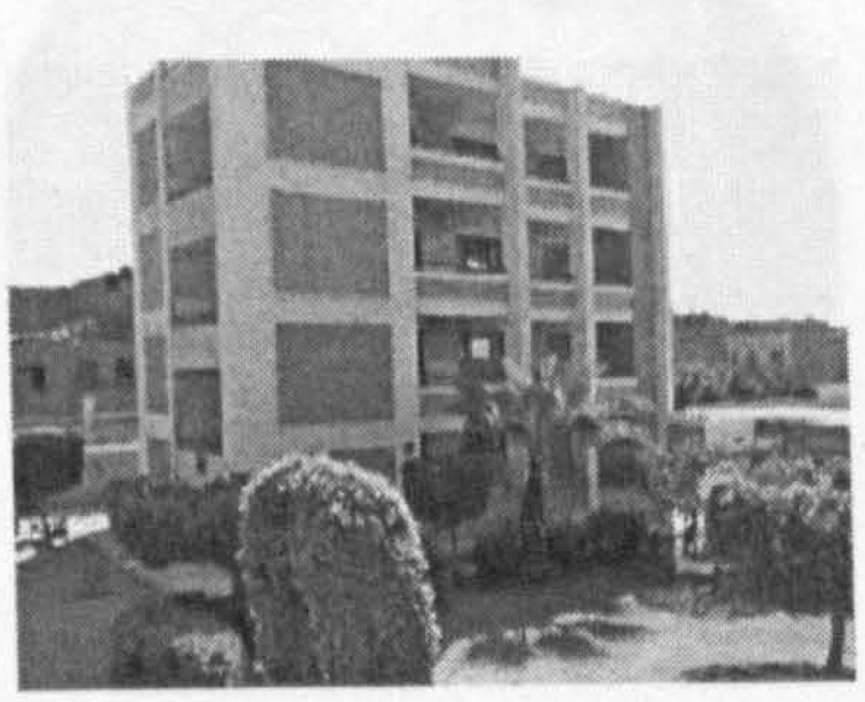


Figure 68: External view of case study-18

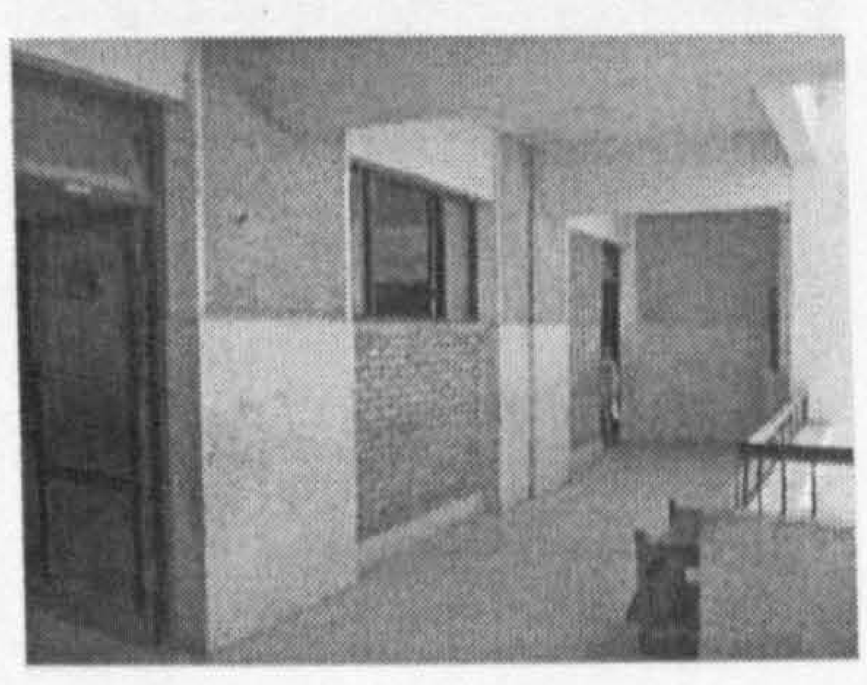


Figure 69: The school corridor in a typical floor of case study-18

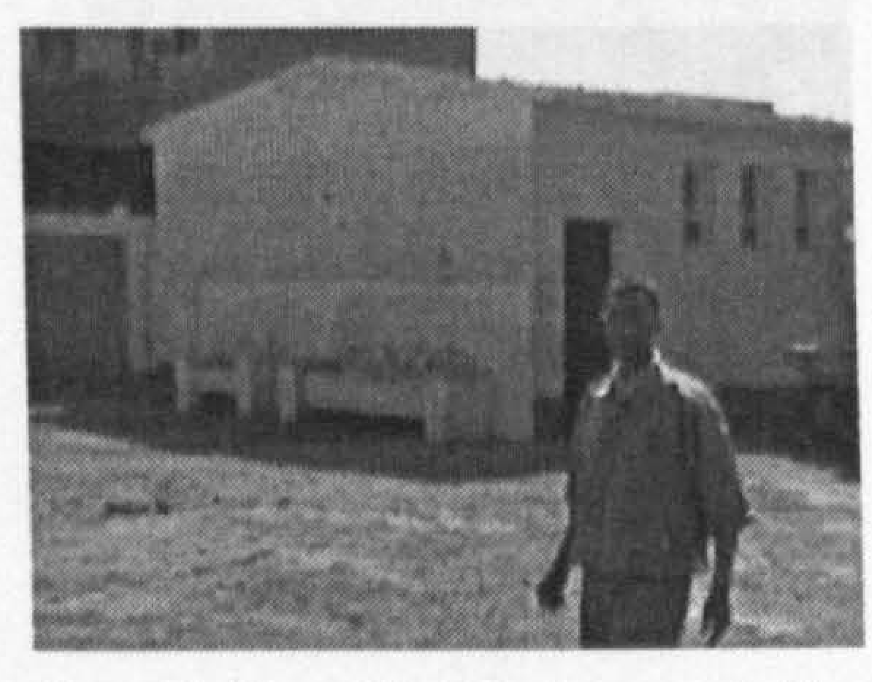


Figure 70: The outside toilets in case study-18

Case study-19 – Al-Lamaty

Location	Al-Minya City	
Prototype	T12 - a	
No., of floors	Five	
Components	Twelve classrooms in addition to administrative spaces, services and activities spaces. With attached nursery in the ground floor (refer to the drawings of T12-a prototype)	
Classroom's density		45 student/class
Description		This school is located in urban context, in the heart of the al-Minya city. The school buildings is surrounded by three streets from three directions, and the fourth one is a school buildings in the South West.
Surroundings	North	The playground
	East	Main street (12 m)
	South	Sub-main street (8 m)
	West	School building (9 m height)

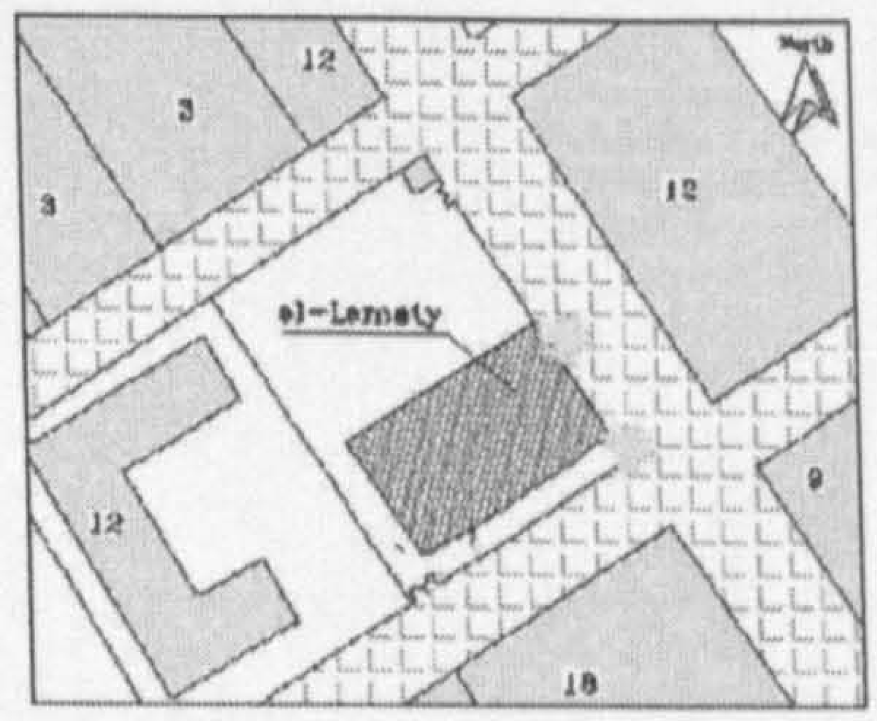


Figure 71: Master plan of case study-19

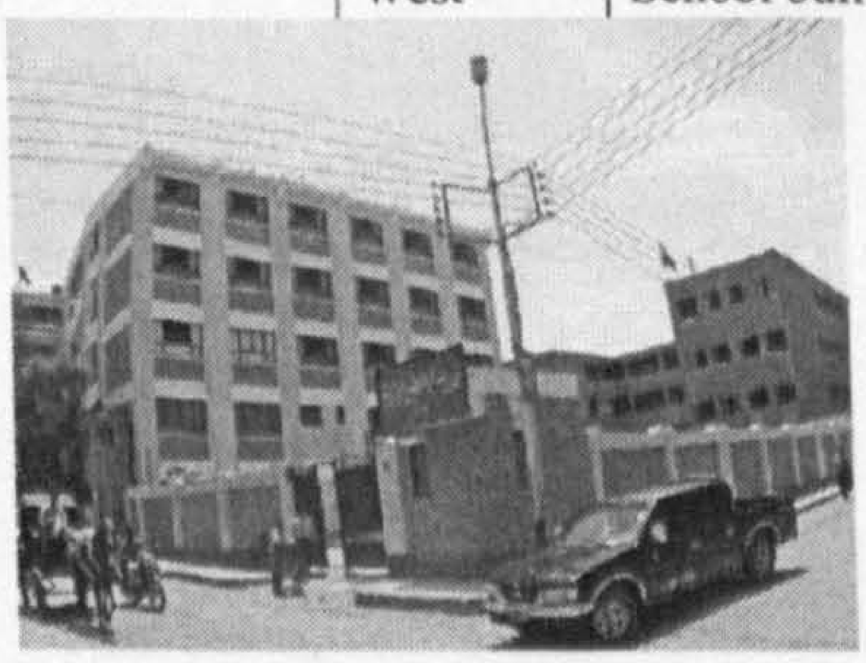


Figure 72: External view of case study-19 from the main street

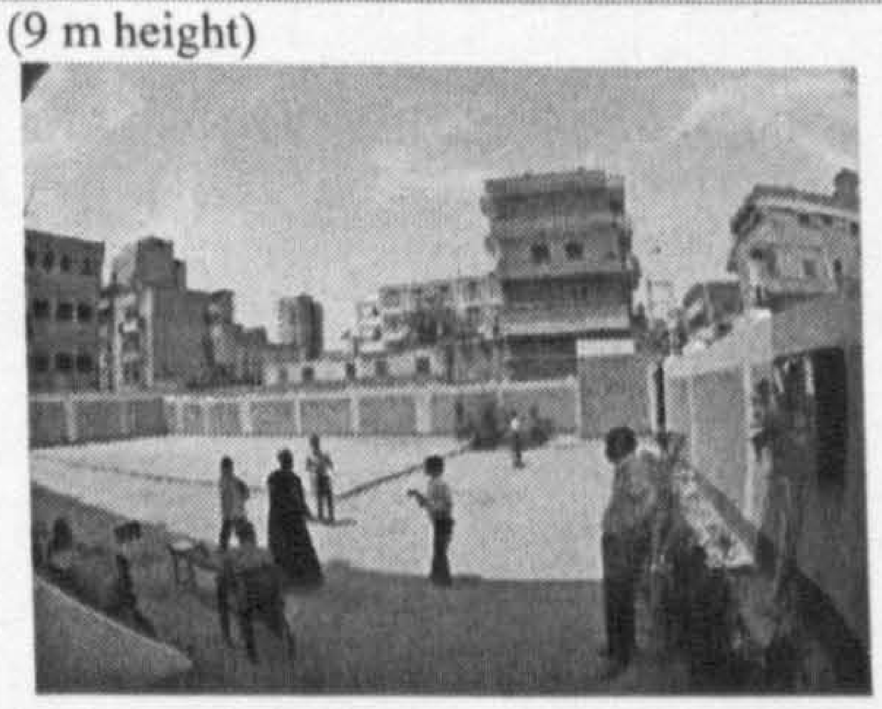


Figure 73: The playground of case study-19

Figure 74: A picture inside the corridor in a typical floor of case stusy-19

Case study-20 - Sekem

Location	Belbis, al-Sharkia	
No., of floors	One	
Components	Six classrooms with additional spaces for a Library, attached open spaces to the classrooms, admin rooms and WCs.	
Classroom's density		45 student/class
Description		This school is located in rural context. The cultivated land surround the school from all directions.

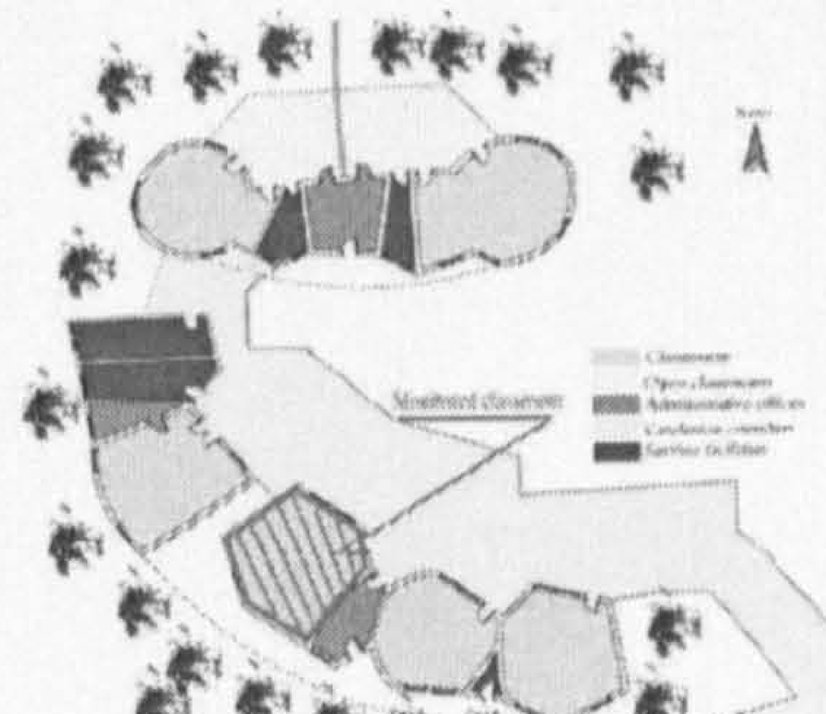


Figure 75: Master plan of case study-20

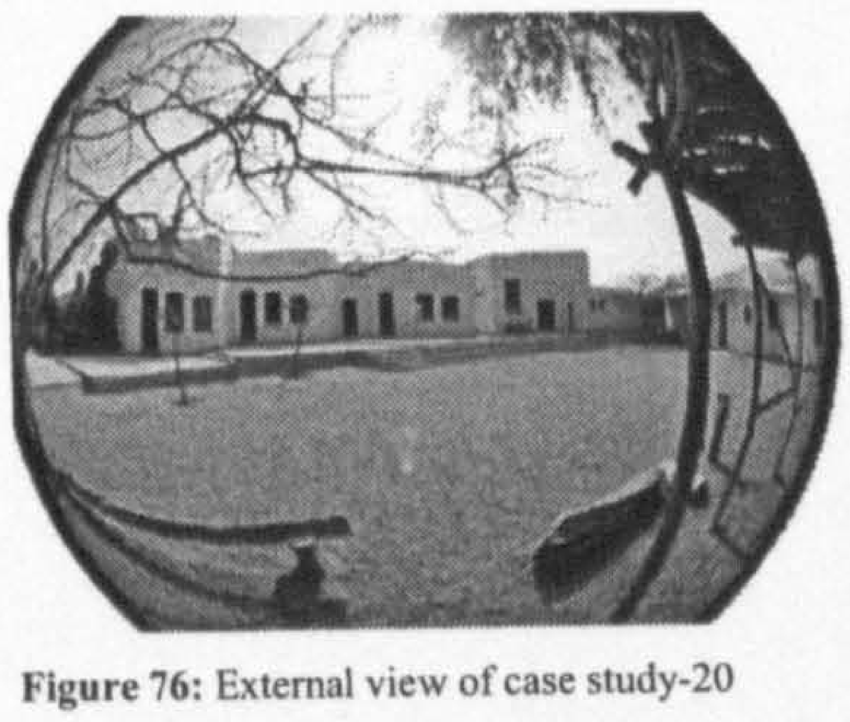


Figure 76: External view of case study-20

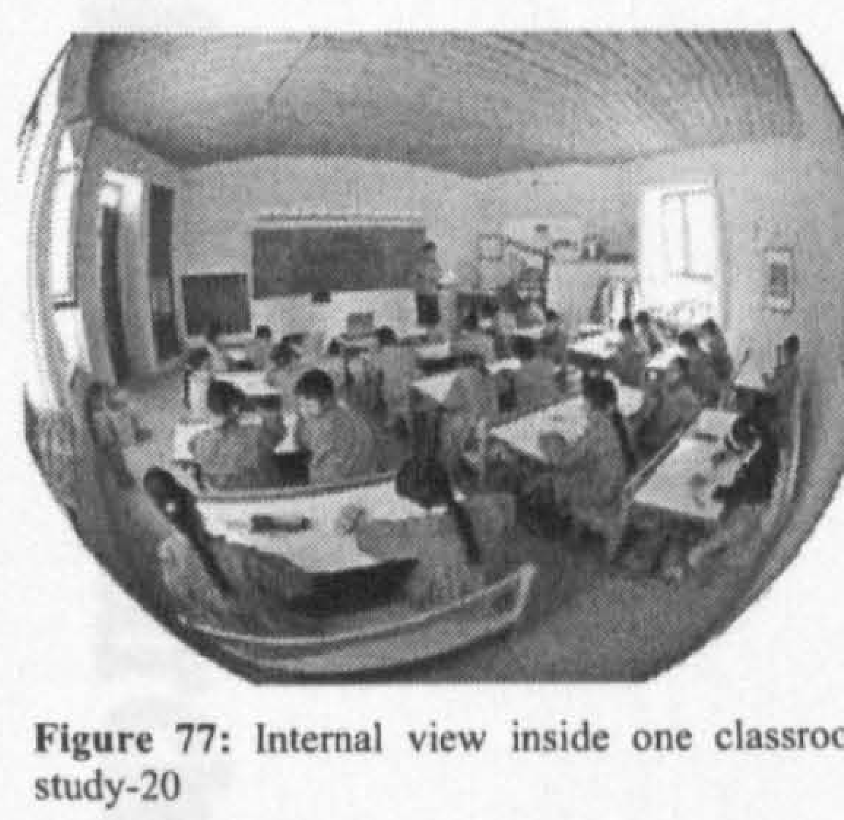


Figure 77: Internal view inside one classroom of case study-20

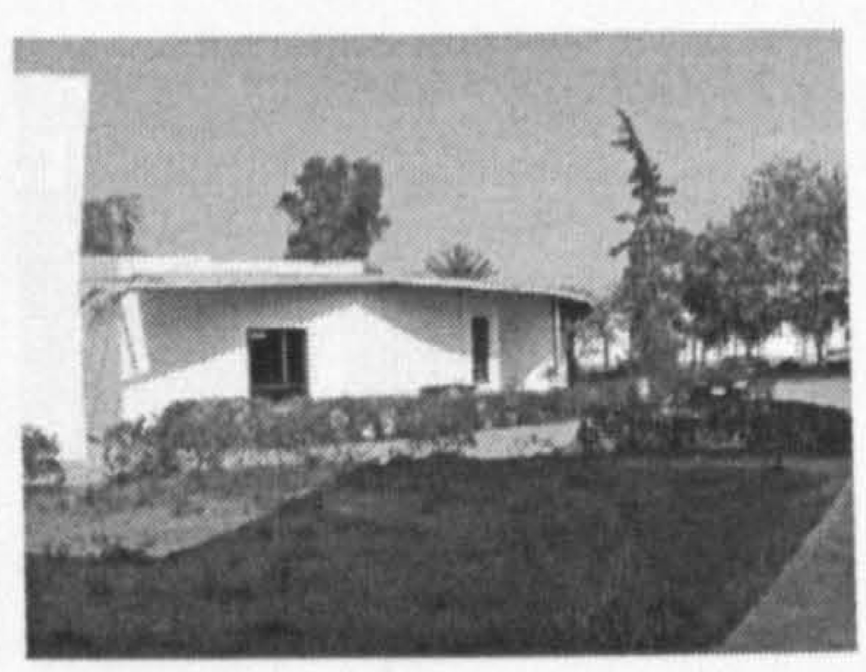
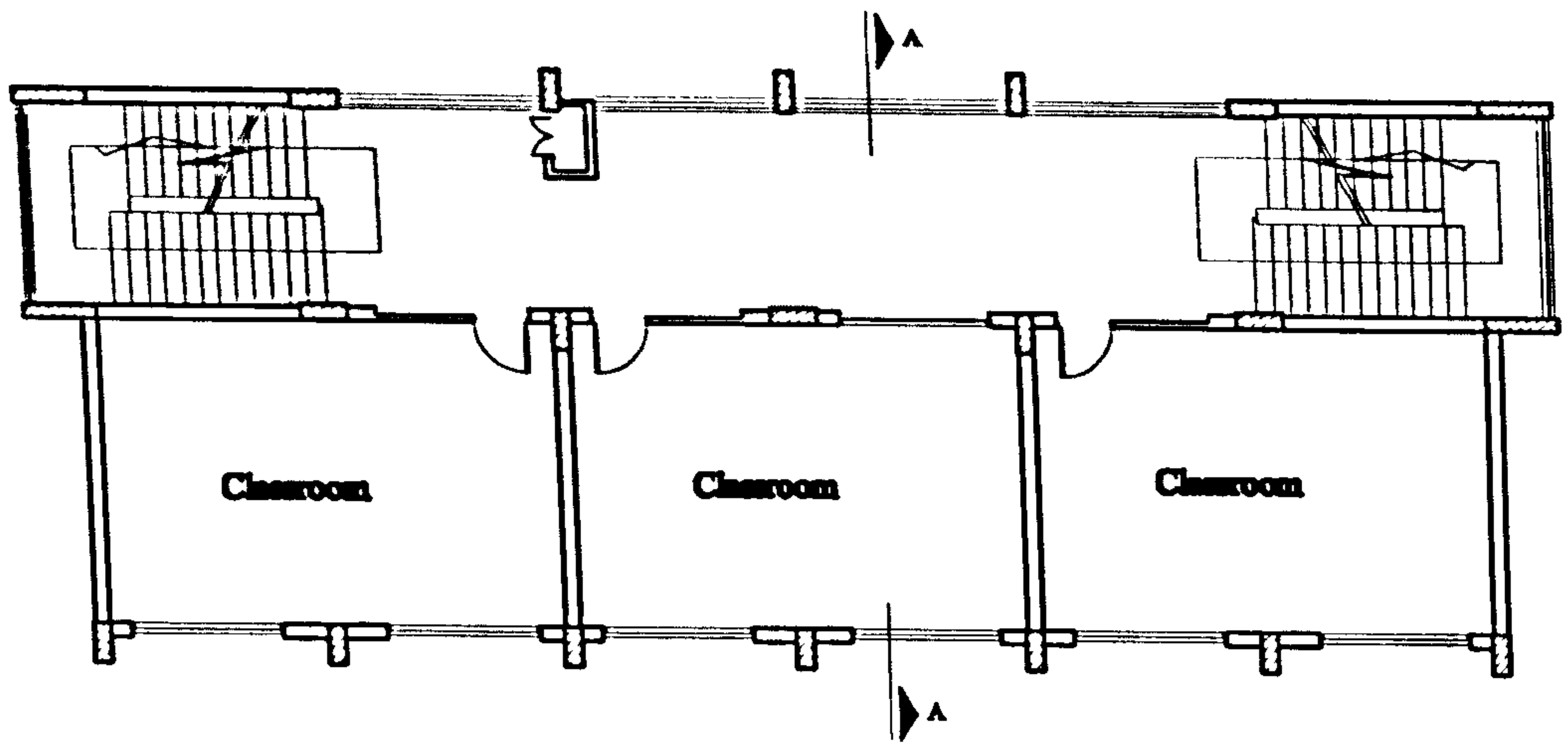
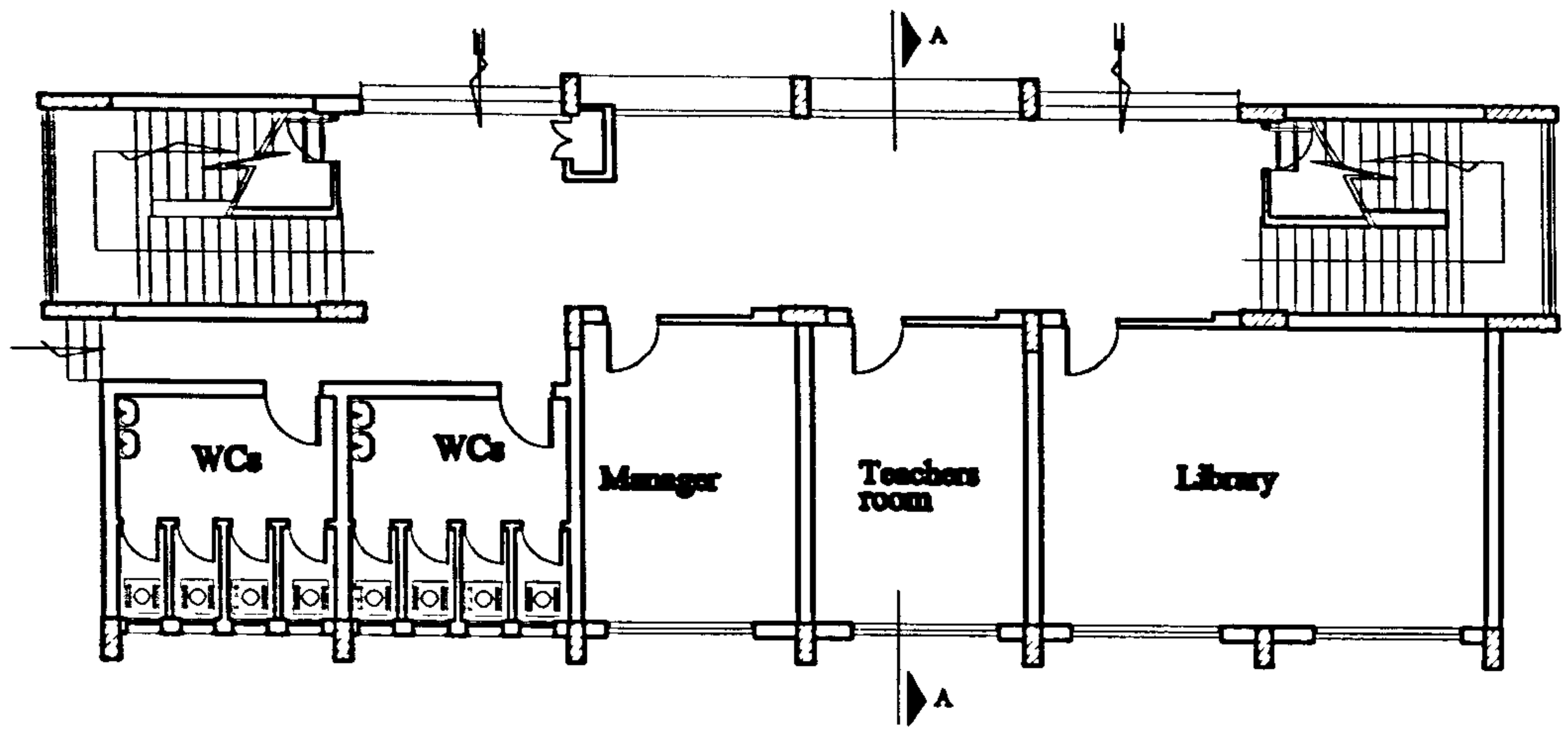


Figure 78: Vegetations around case study-20

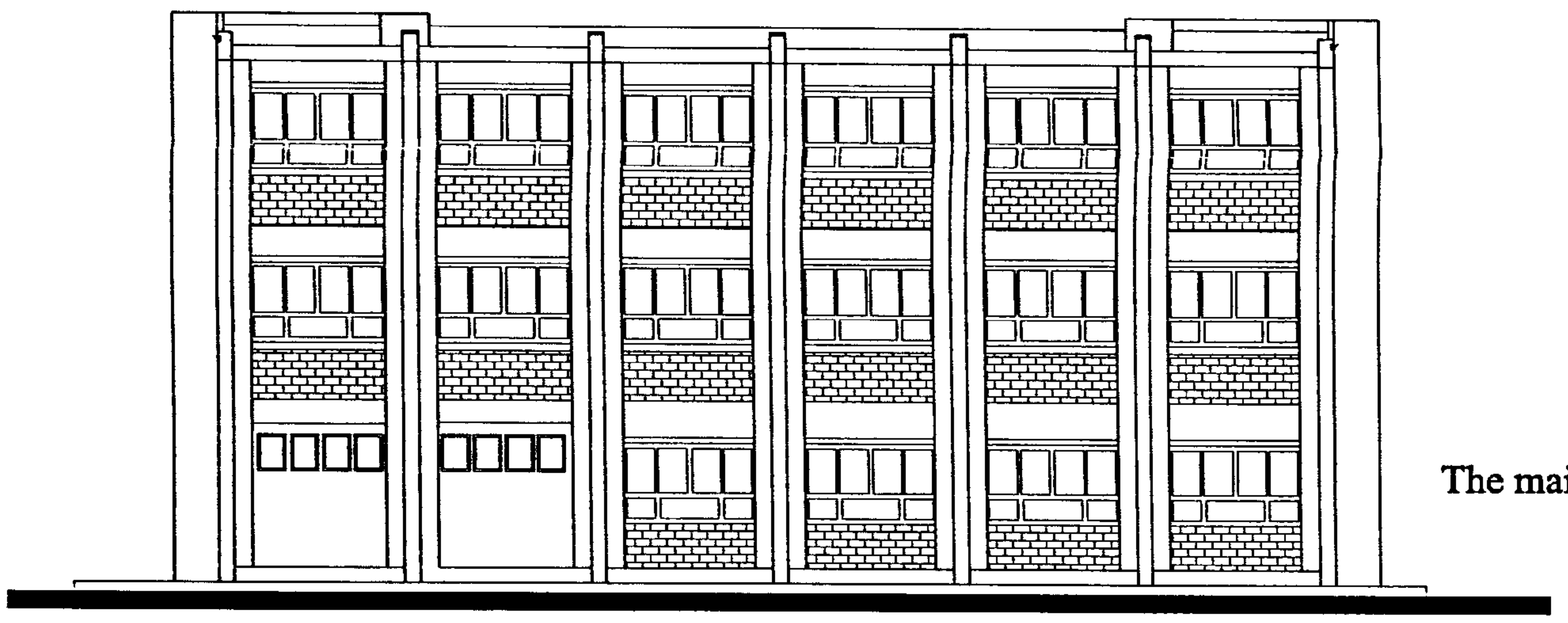
Appendix 5:
Drawings of the case studies of the research



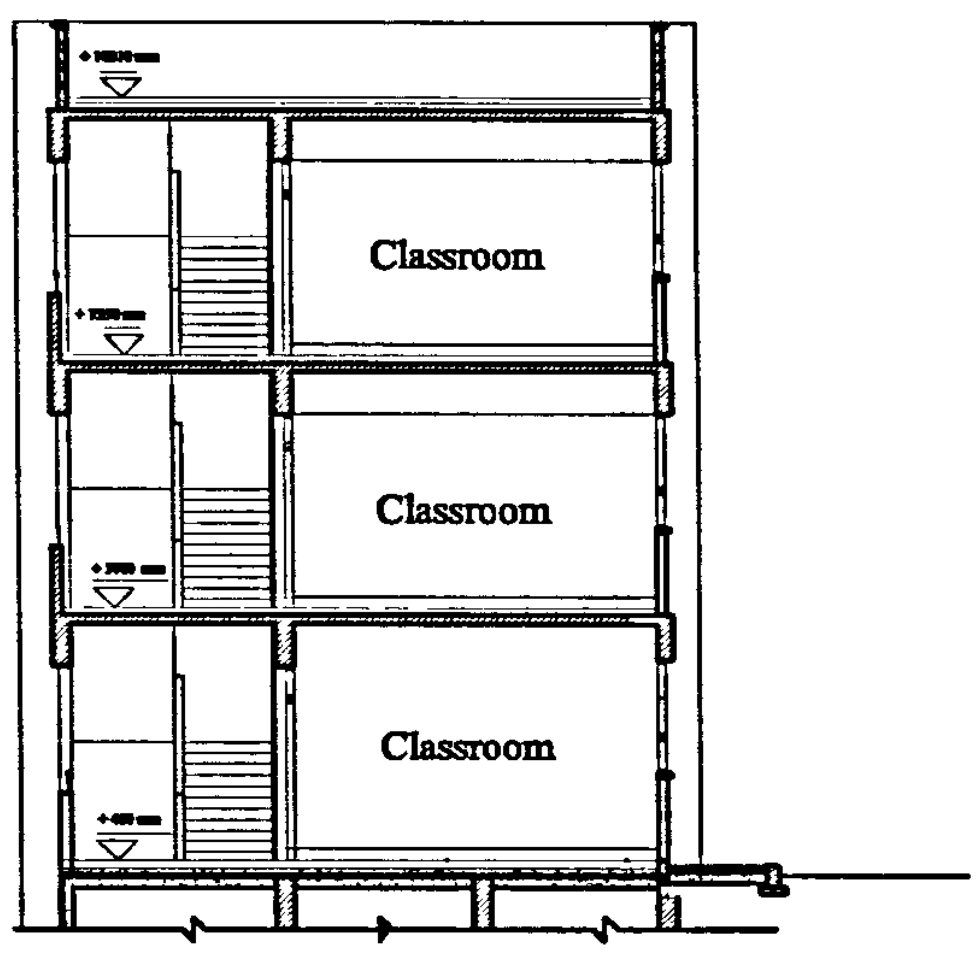
Typical floor



Ground floor

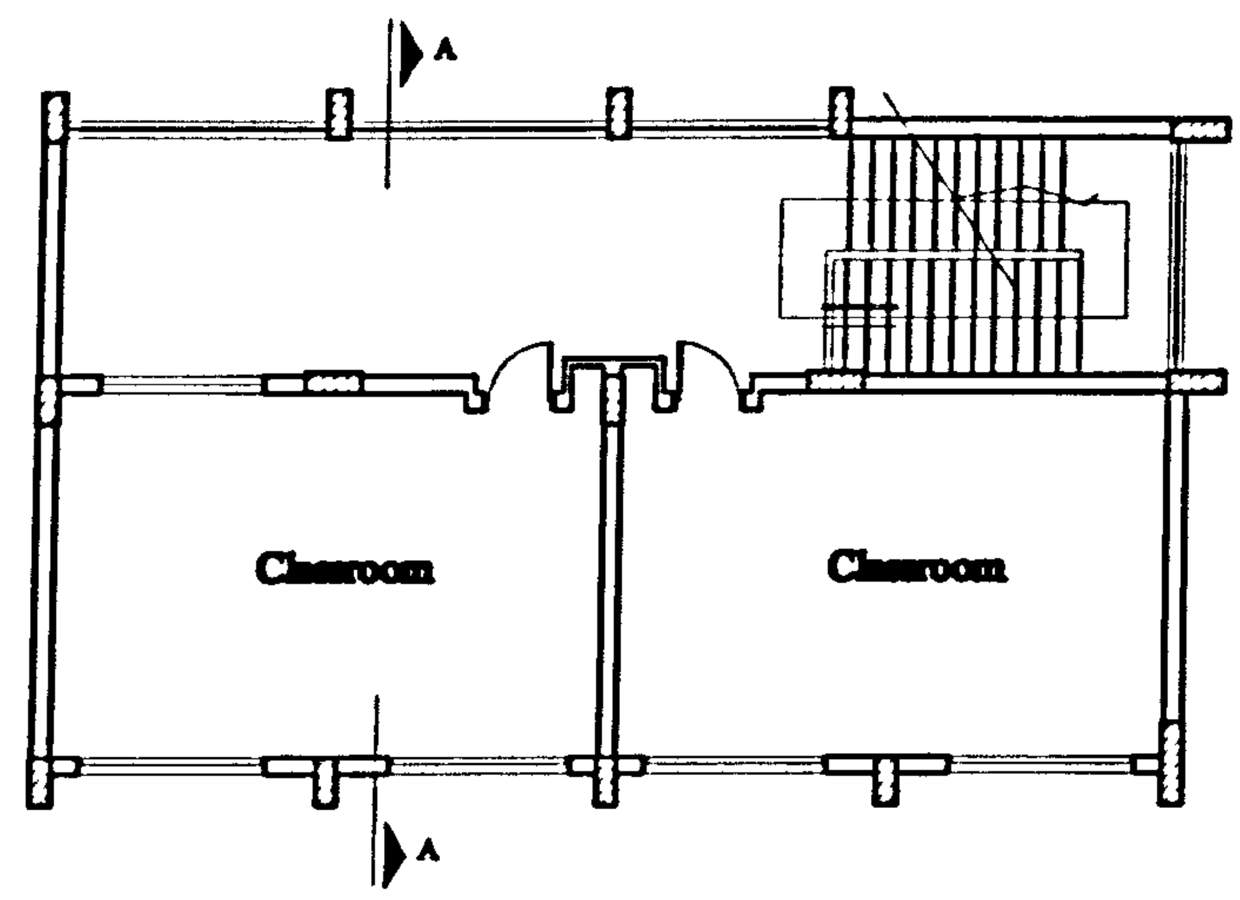


The main Elevation

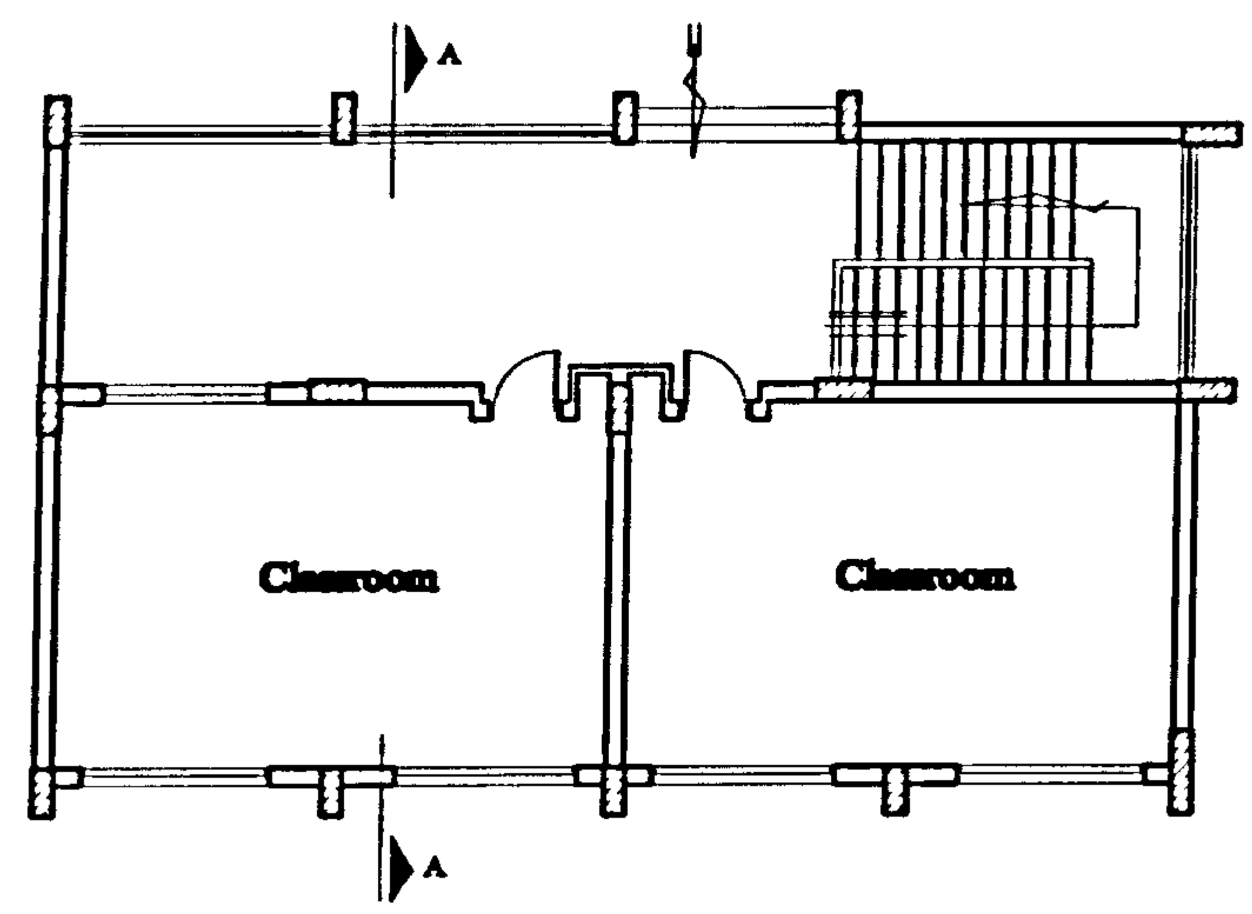


Vertical section A-A

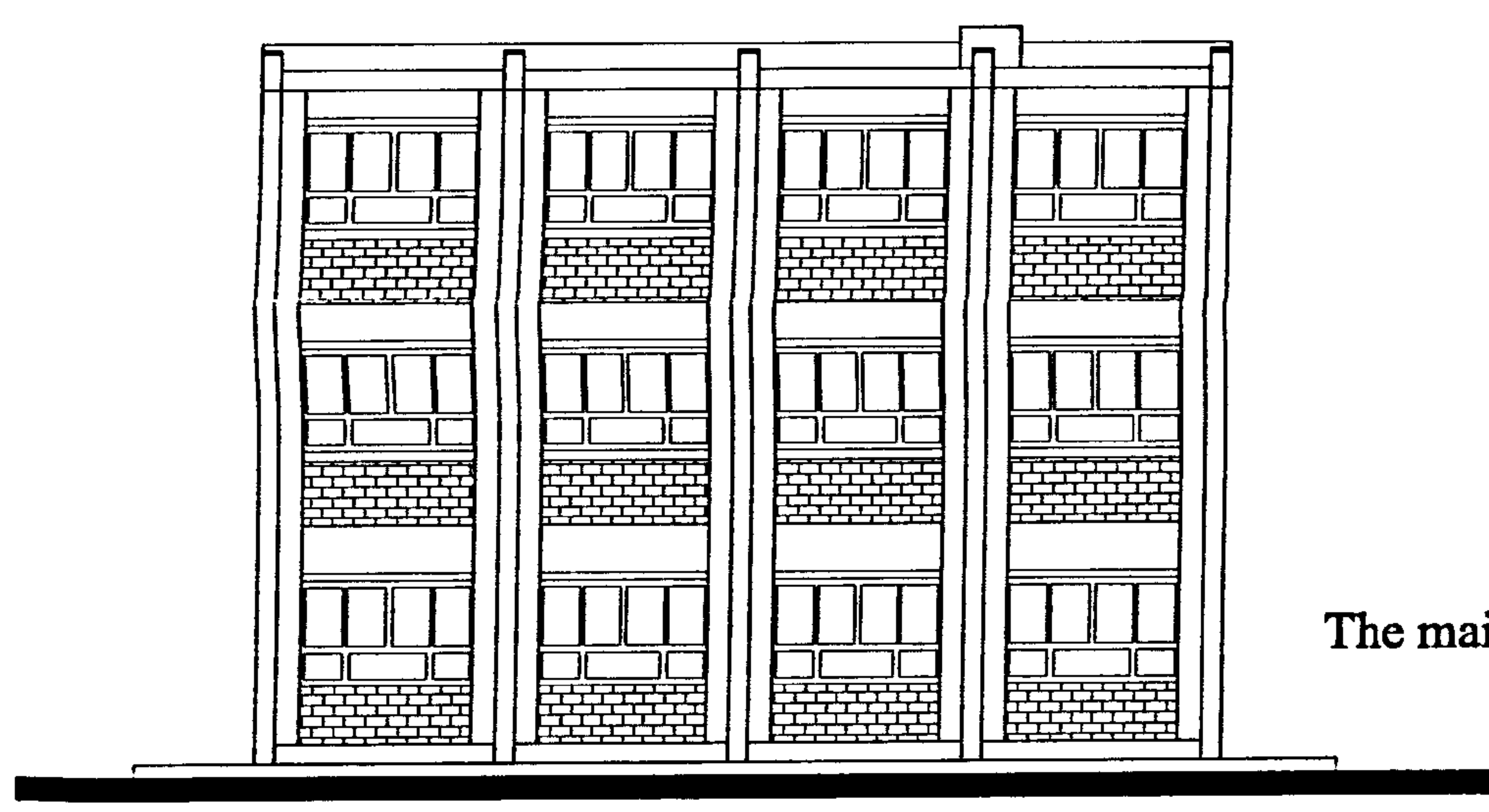
Prototype	Scale	Number of floors	References	
T6 - a	1/200	3	Prepared by the author after the General Authority of Educational Buildings	1



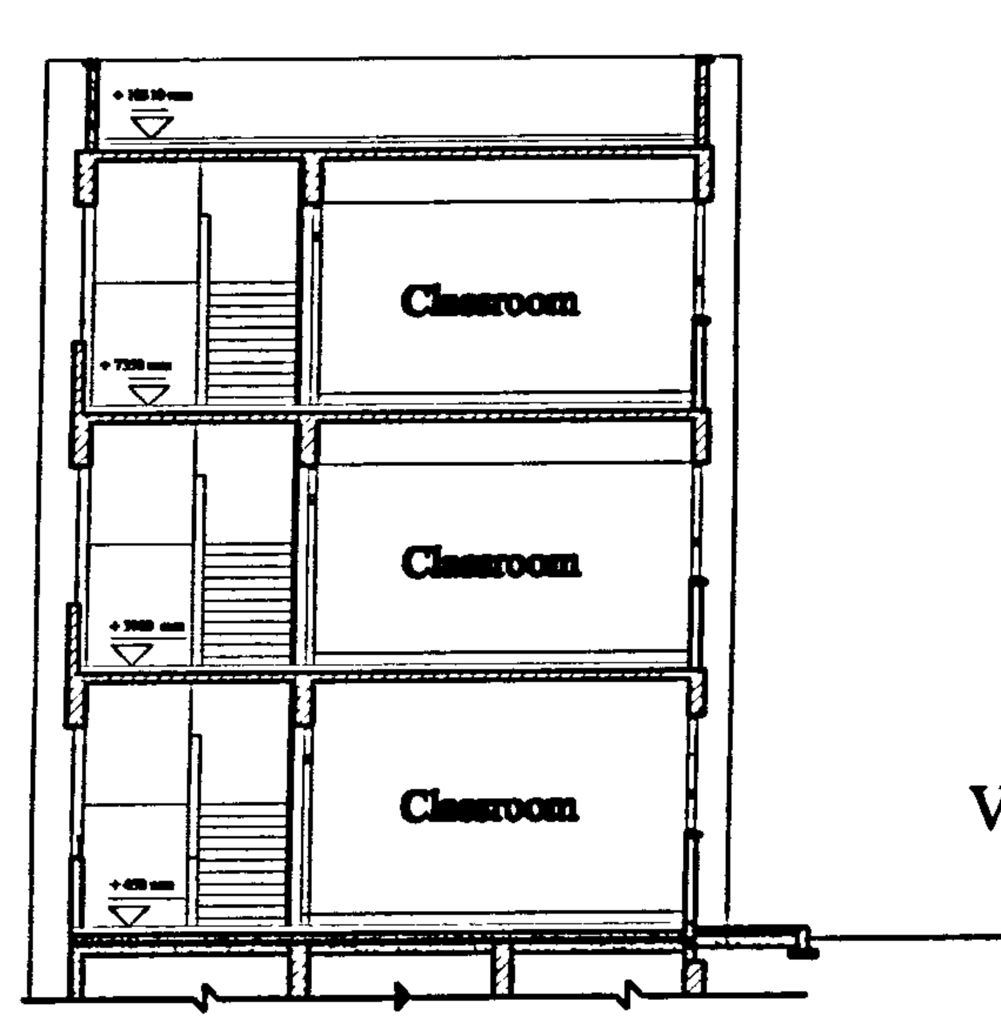
Typical floor



Ground floor

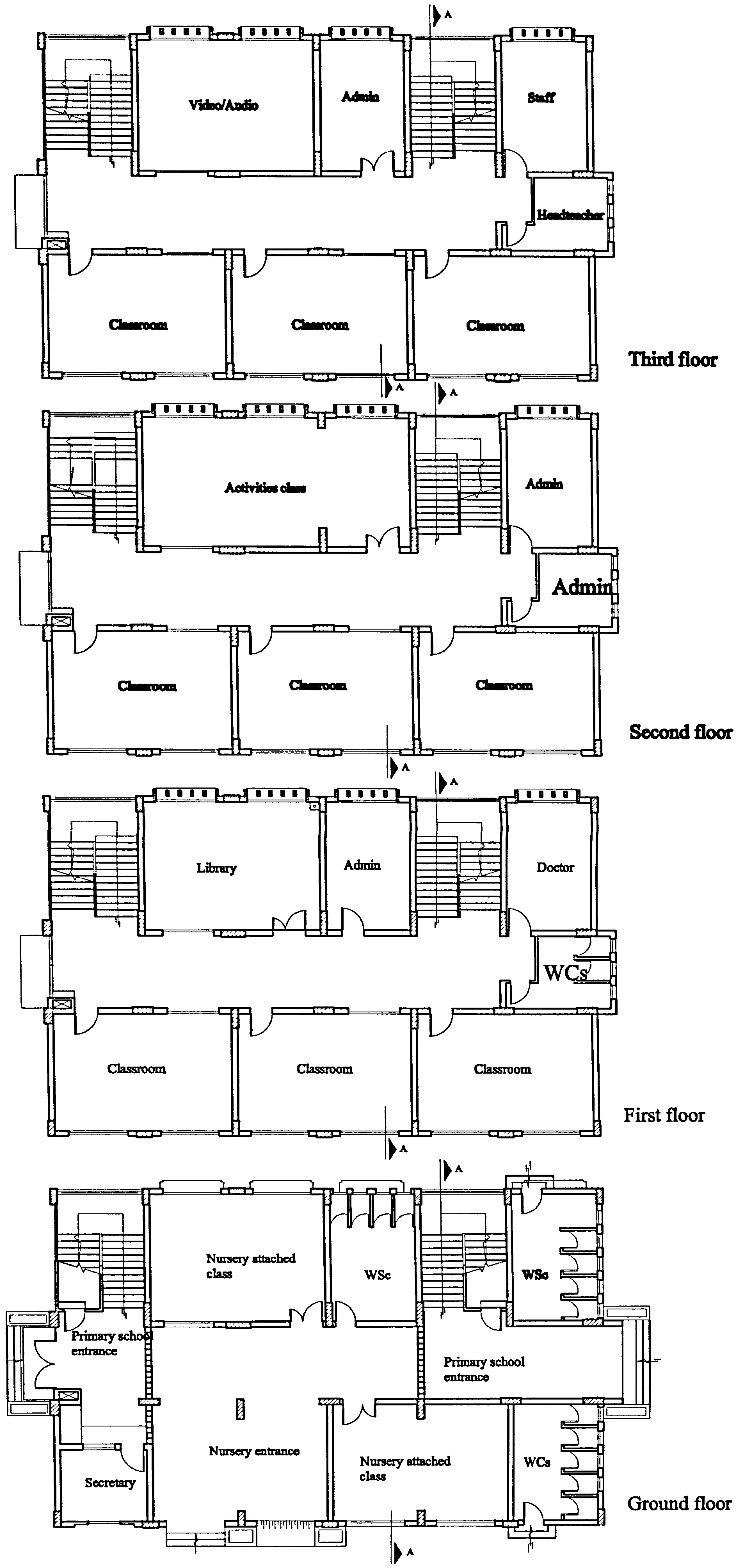


The main Elevation

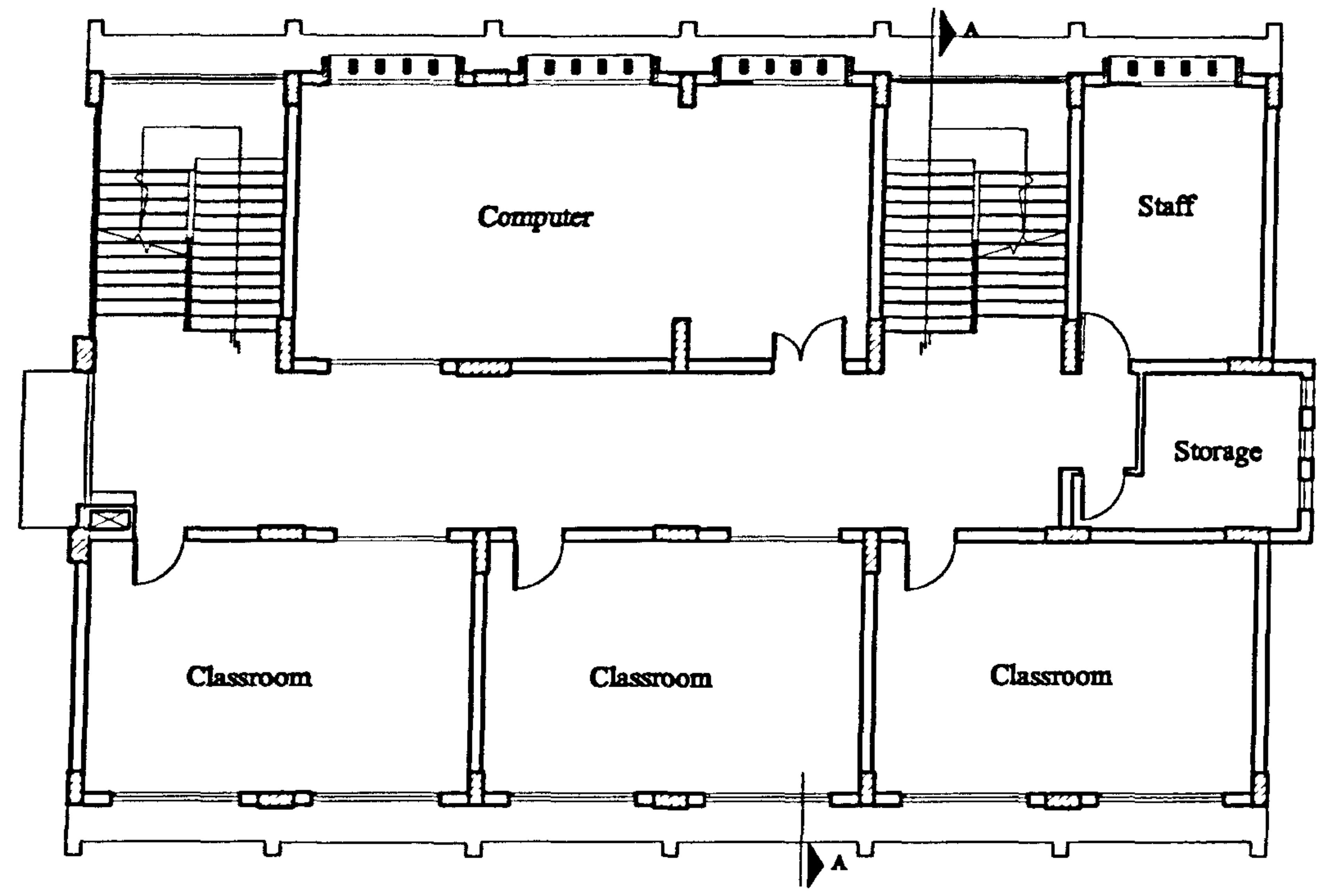


Vertical section A-A

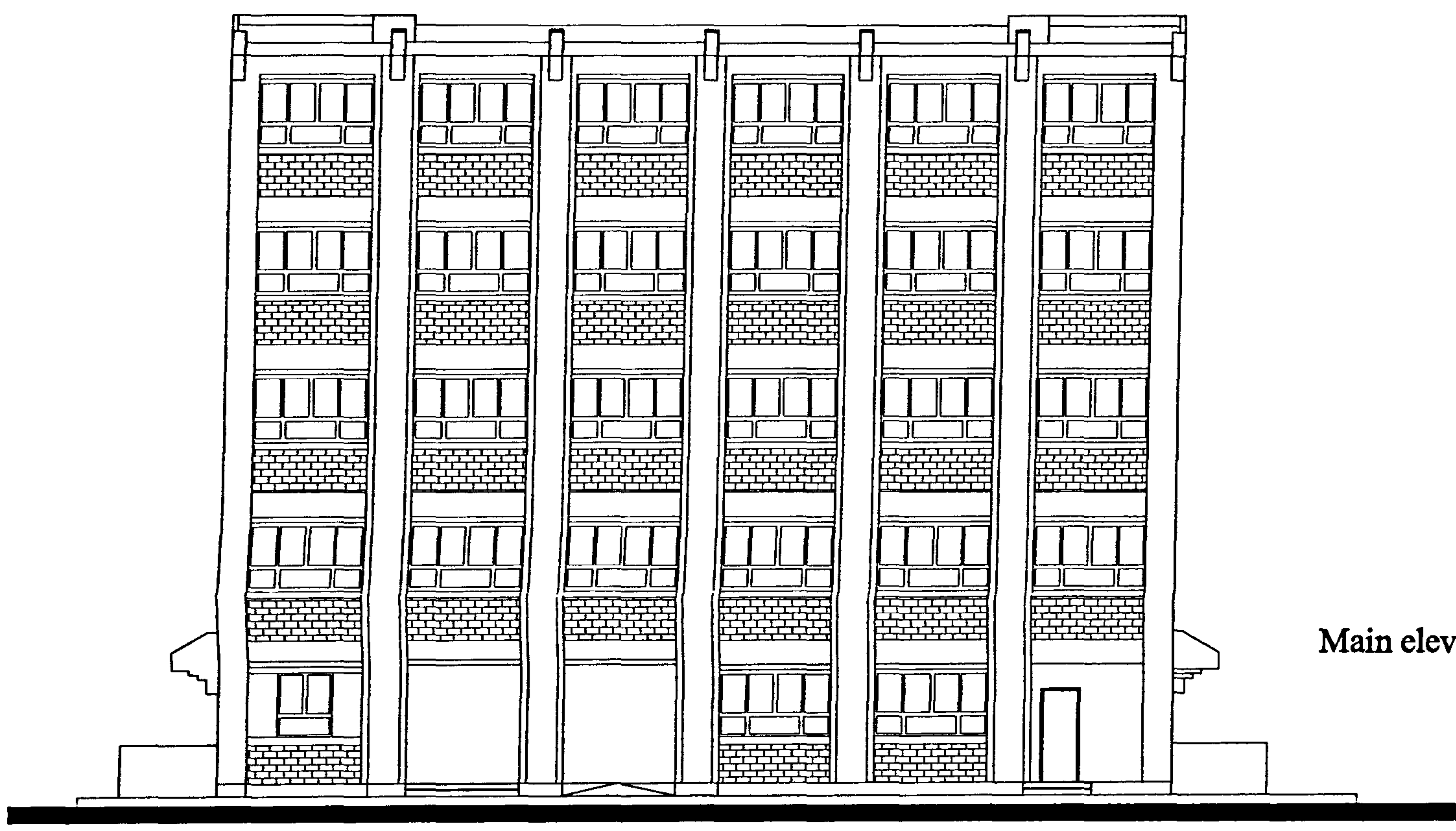
Prototype	Scale	Number of floors	References	
T6 - b	1/200	3	Prepared by the author after the General Authority of Educational Buildings	2



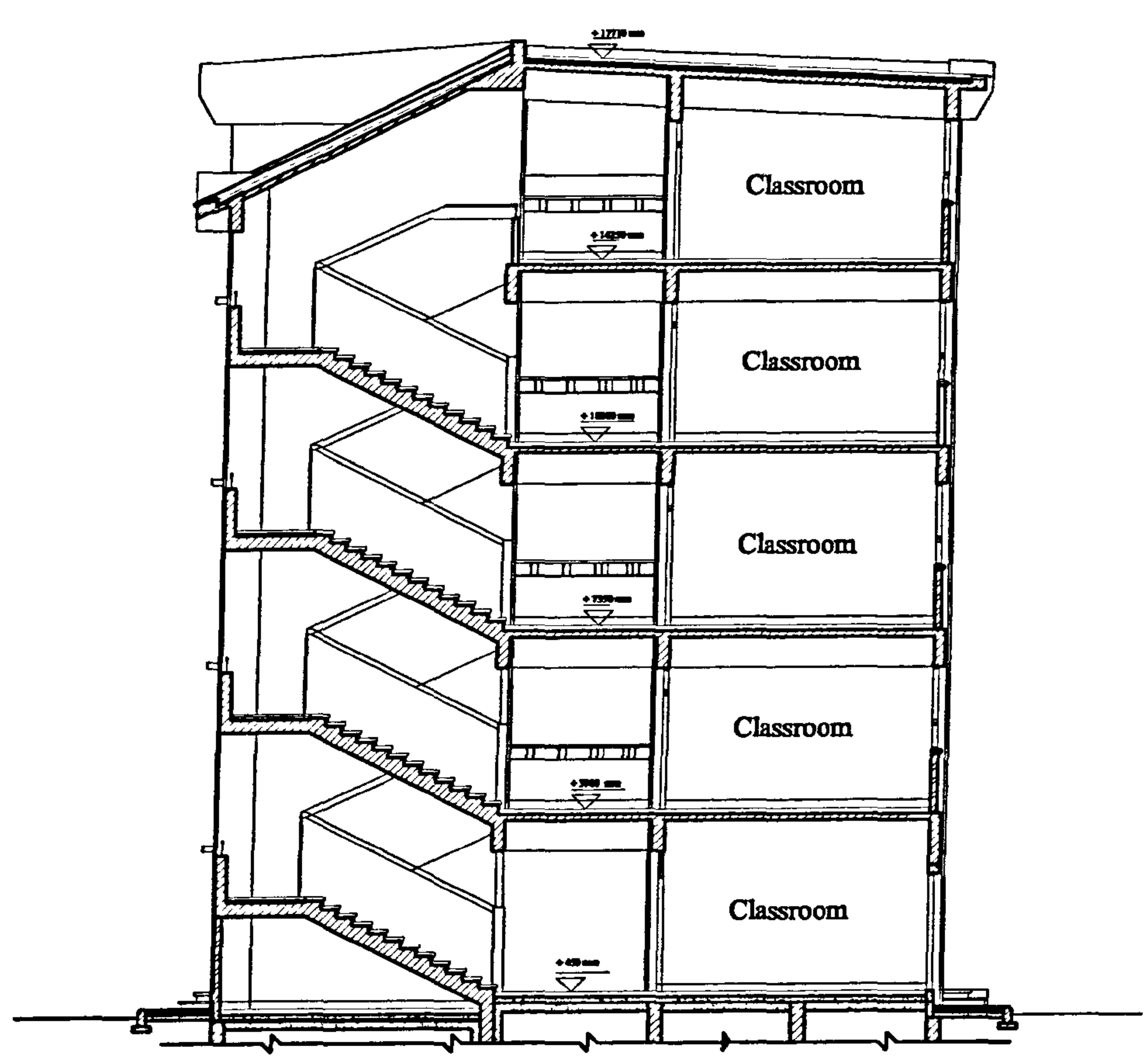
Prototype	Scale	Number of floors	References	
T12 - a	1/200	5	Prepared by the author after the General Authority of Educational Buildings	3 - A



Fourth floor

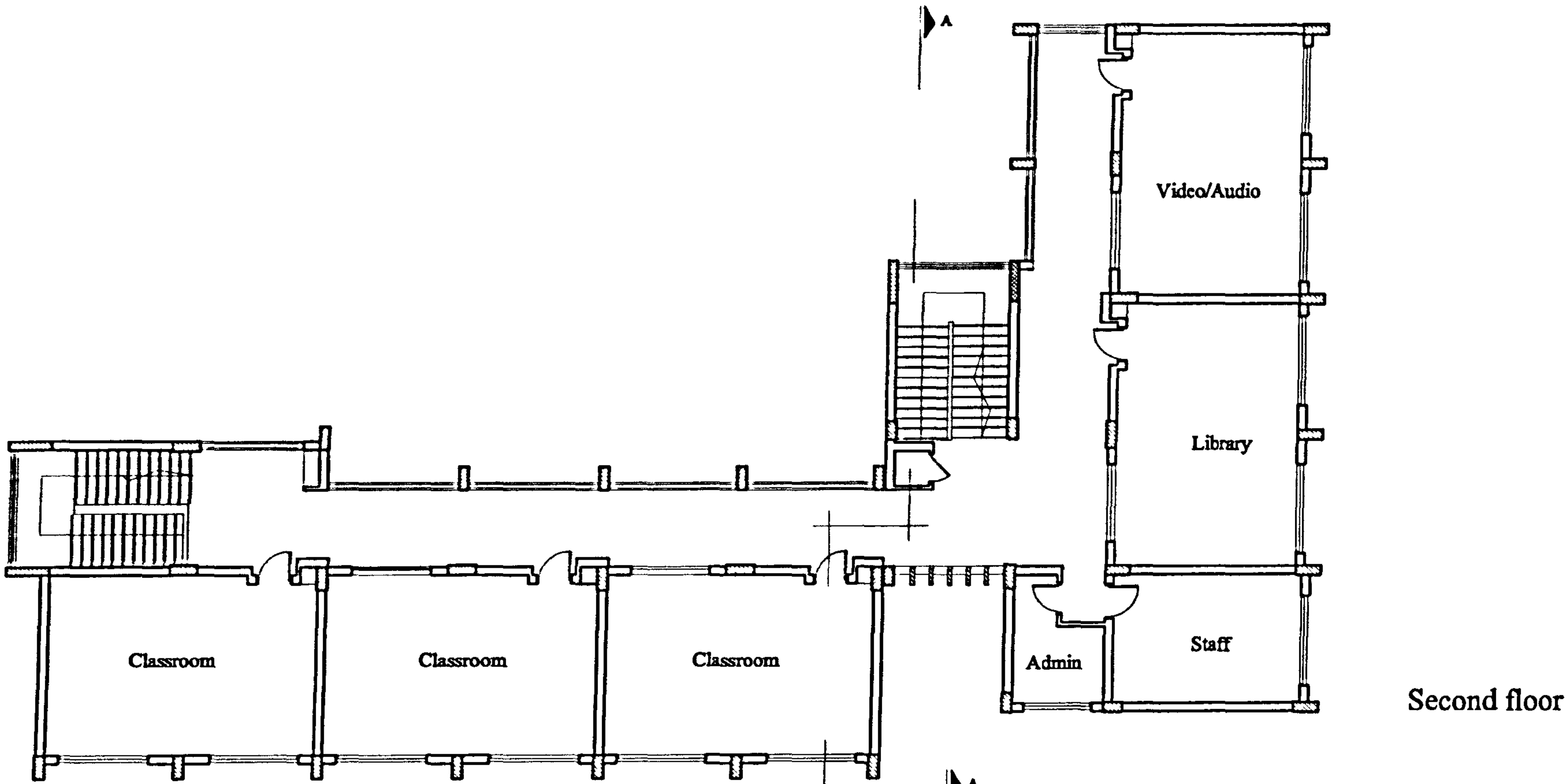


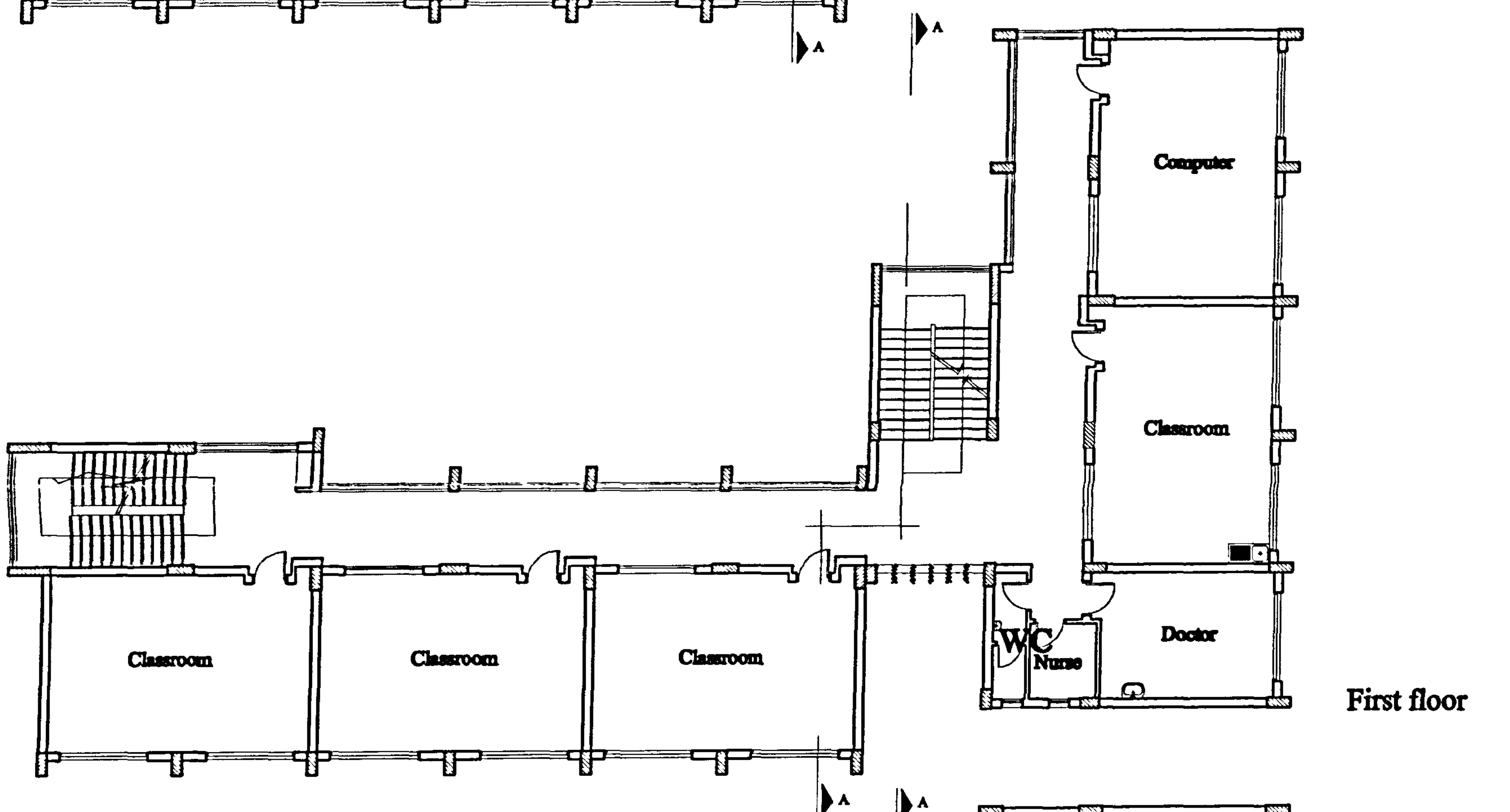
Main elevation

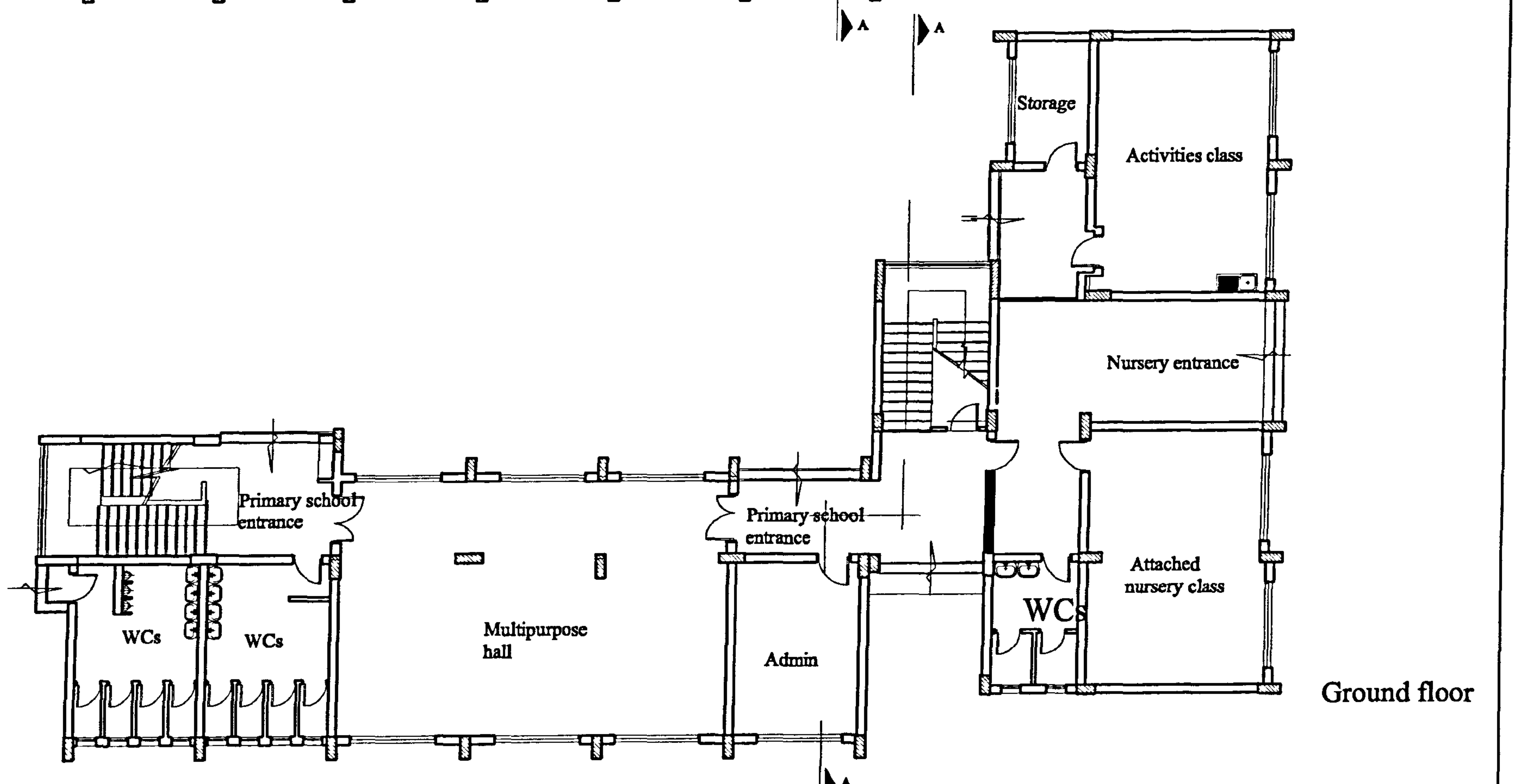


Vertical section A-A

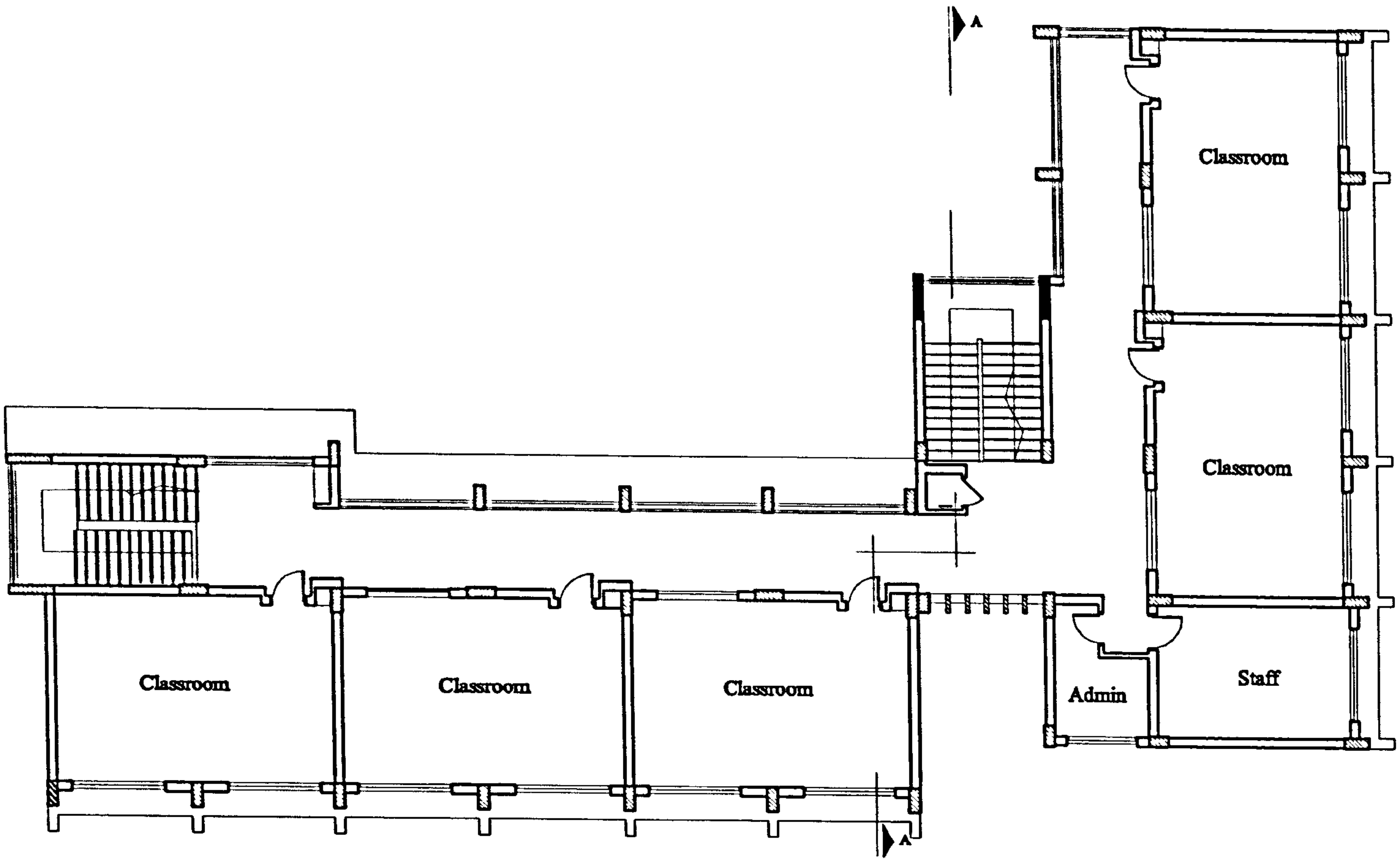
Prototype	Scale	Number of floors	References	
T12 - a	1/200	5	Prepared by the author after the General Authority of Educational Buildings	3 - B



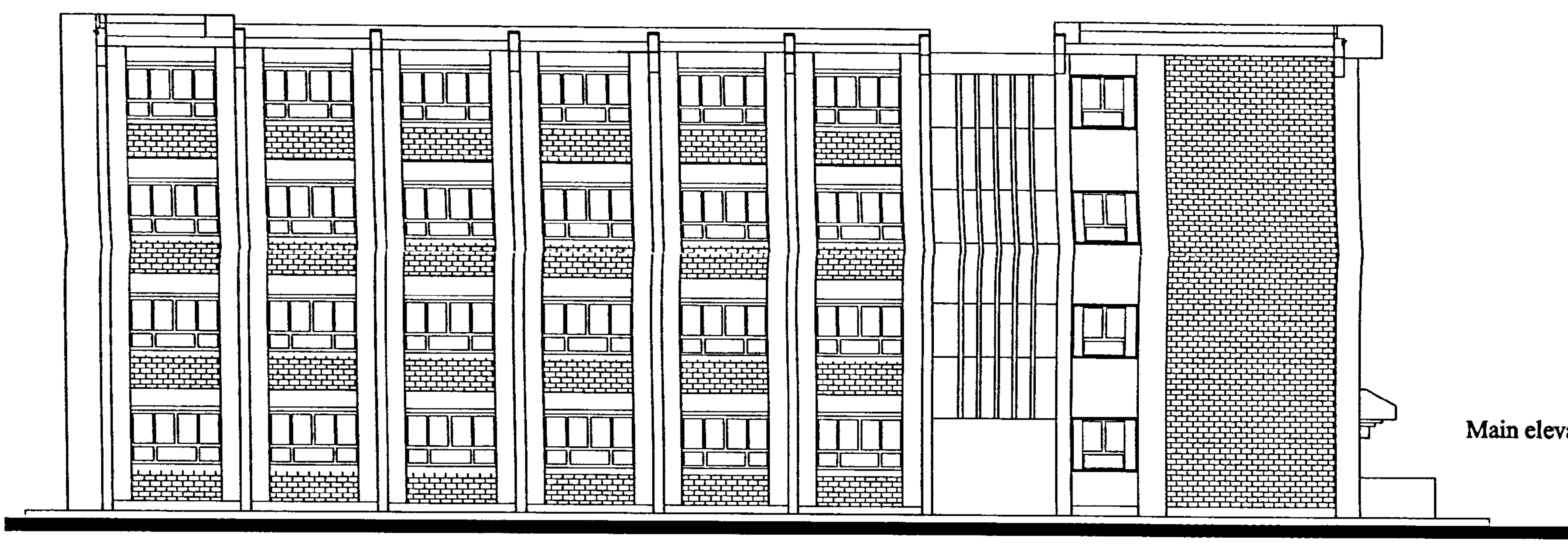




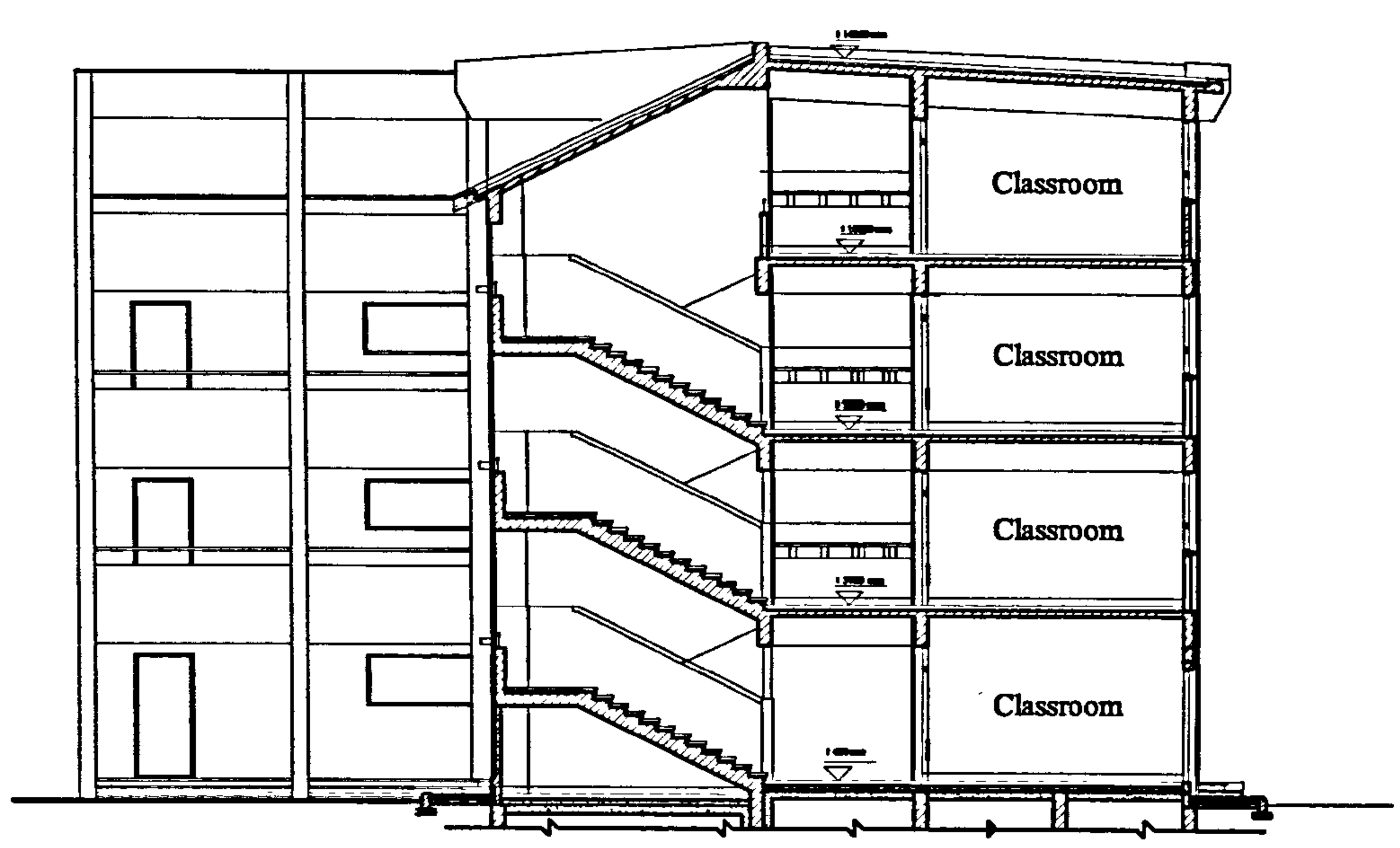
Prototype	Scale	Number of floors	References	
T12 - b	1/200	4	Prepared by the author after the General Authority of Educational Buildings	4 -A



Third floor

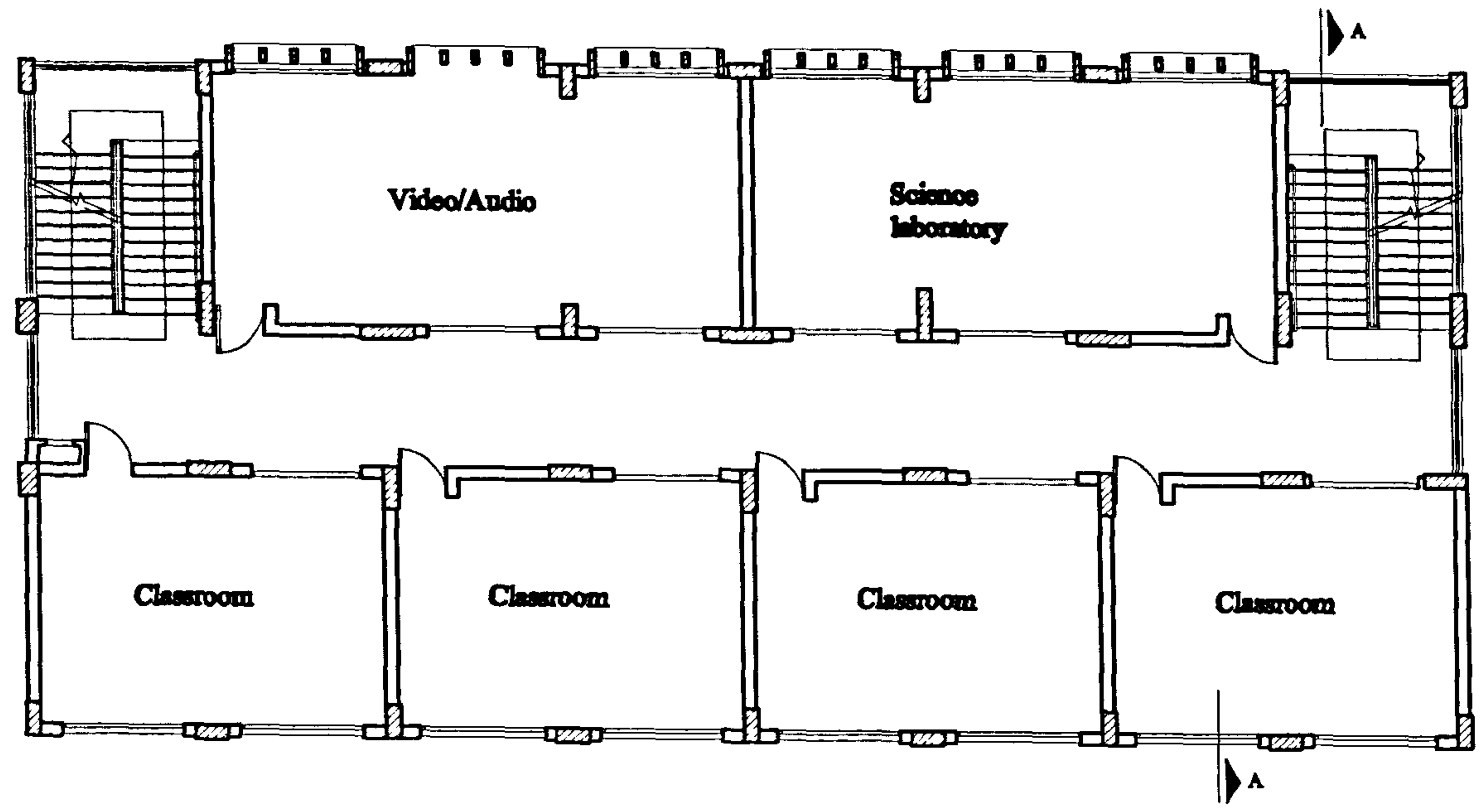


Main elevation

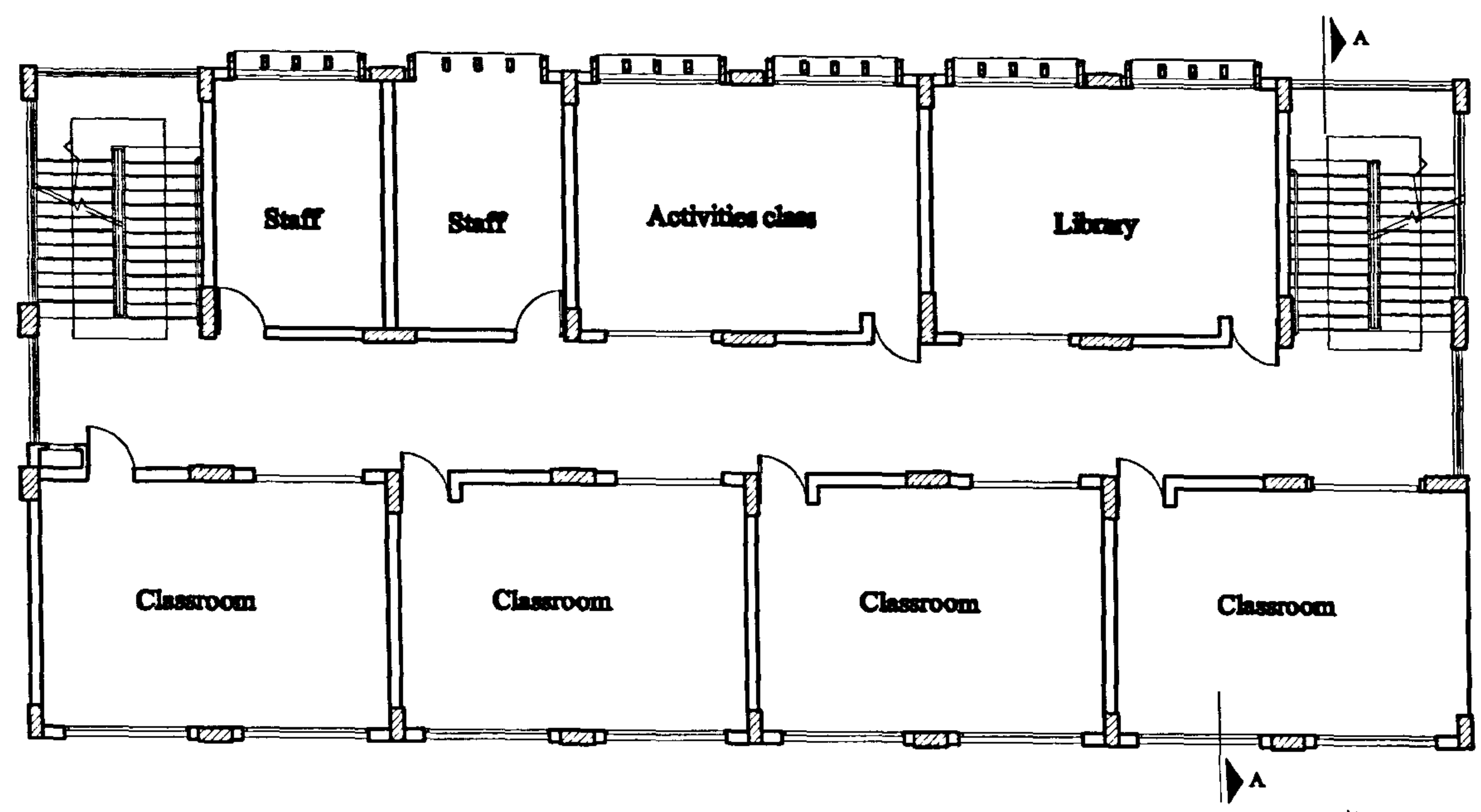


Vertical section A-A

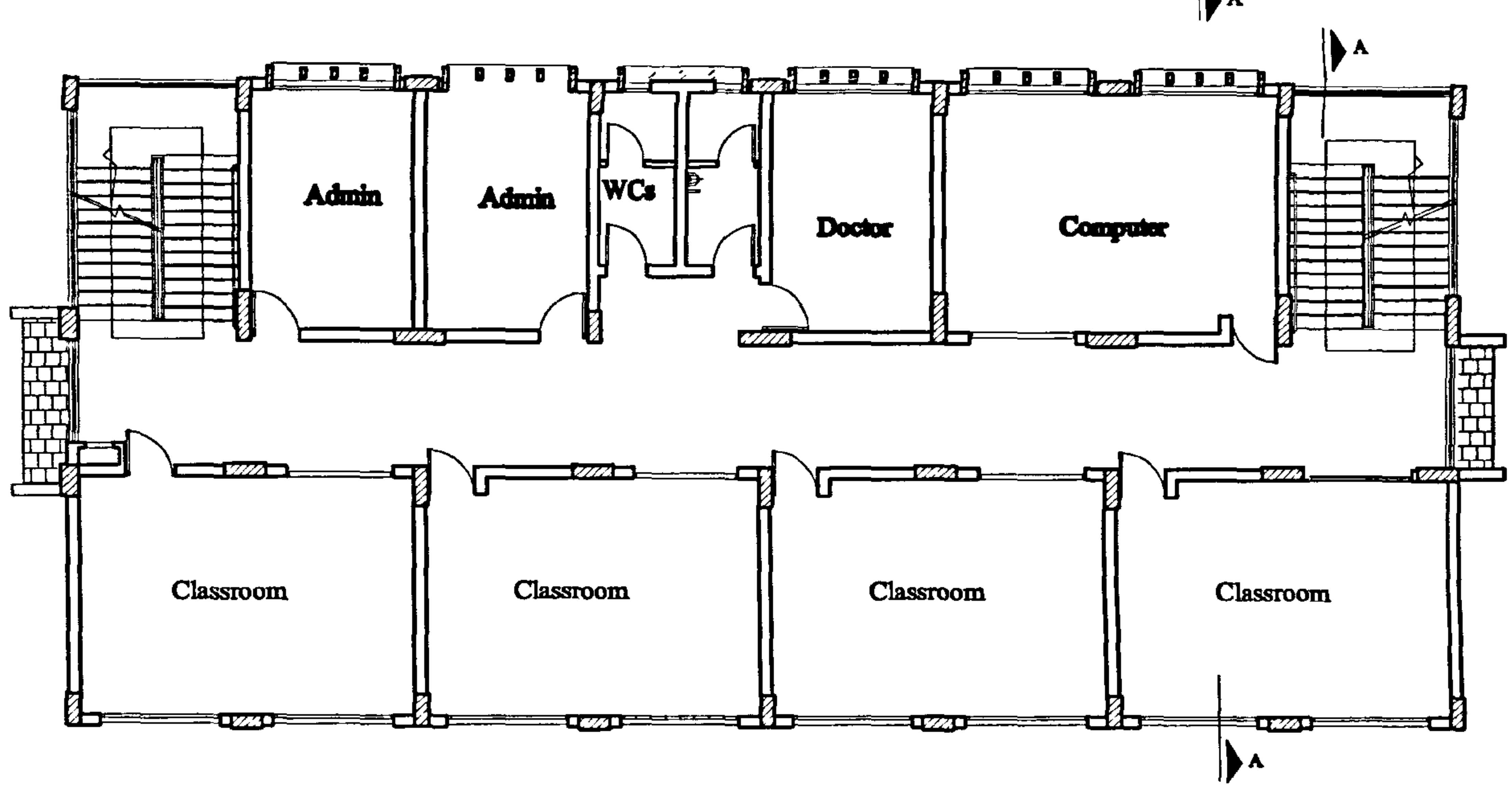
Prototype	Scale	Number of floors	References	
T12 - b	1/200	4	Prepared by the author after the General Authority of Educational Buildings	4 - B



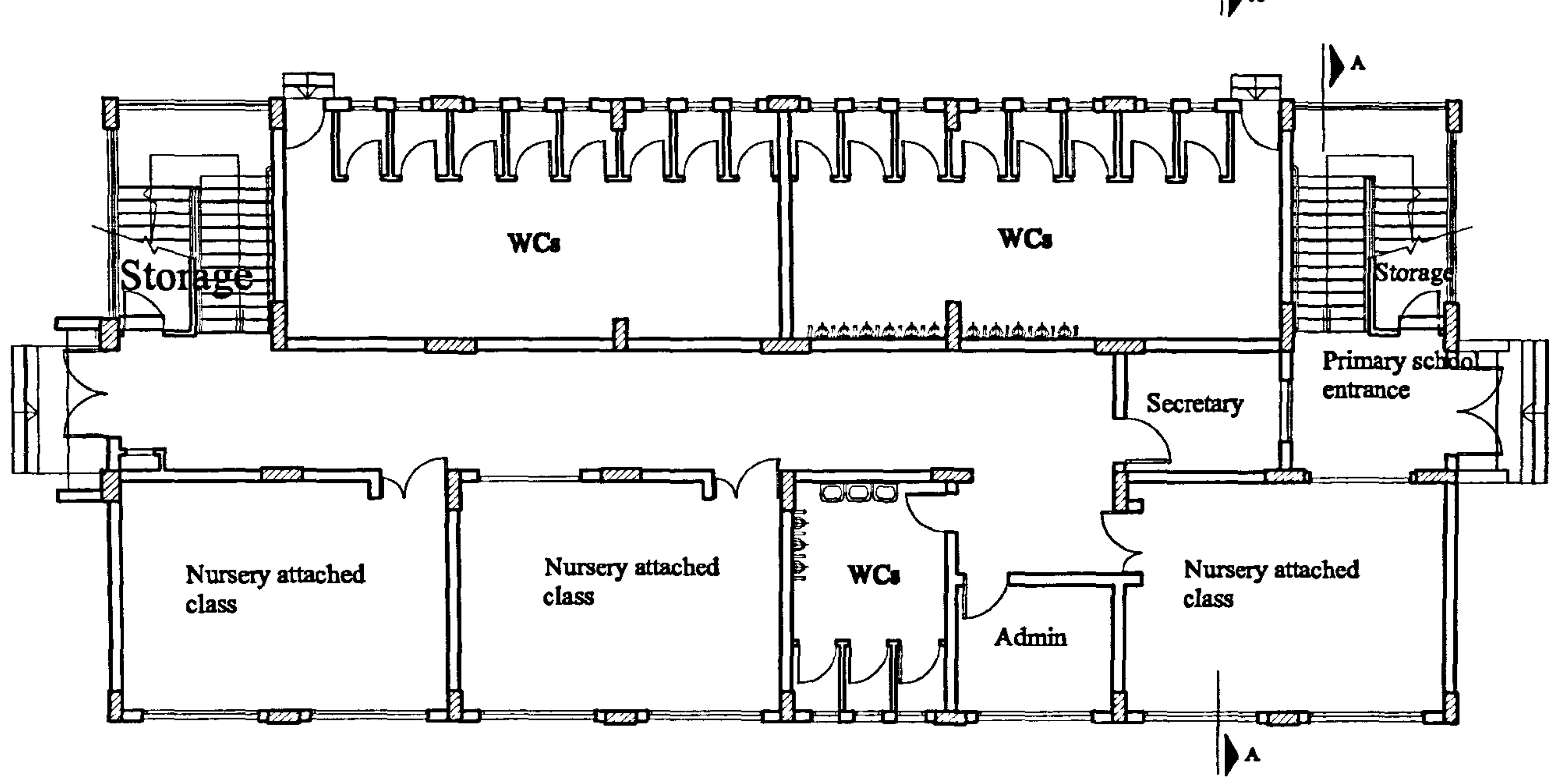
Third floor



Second floor

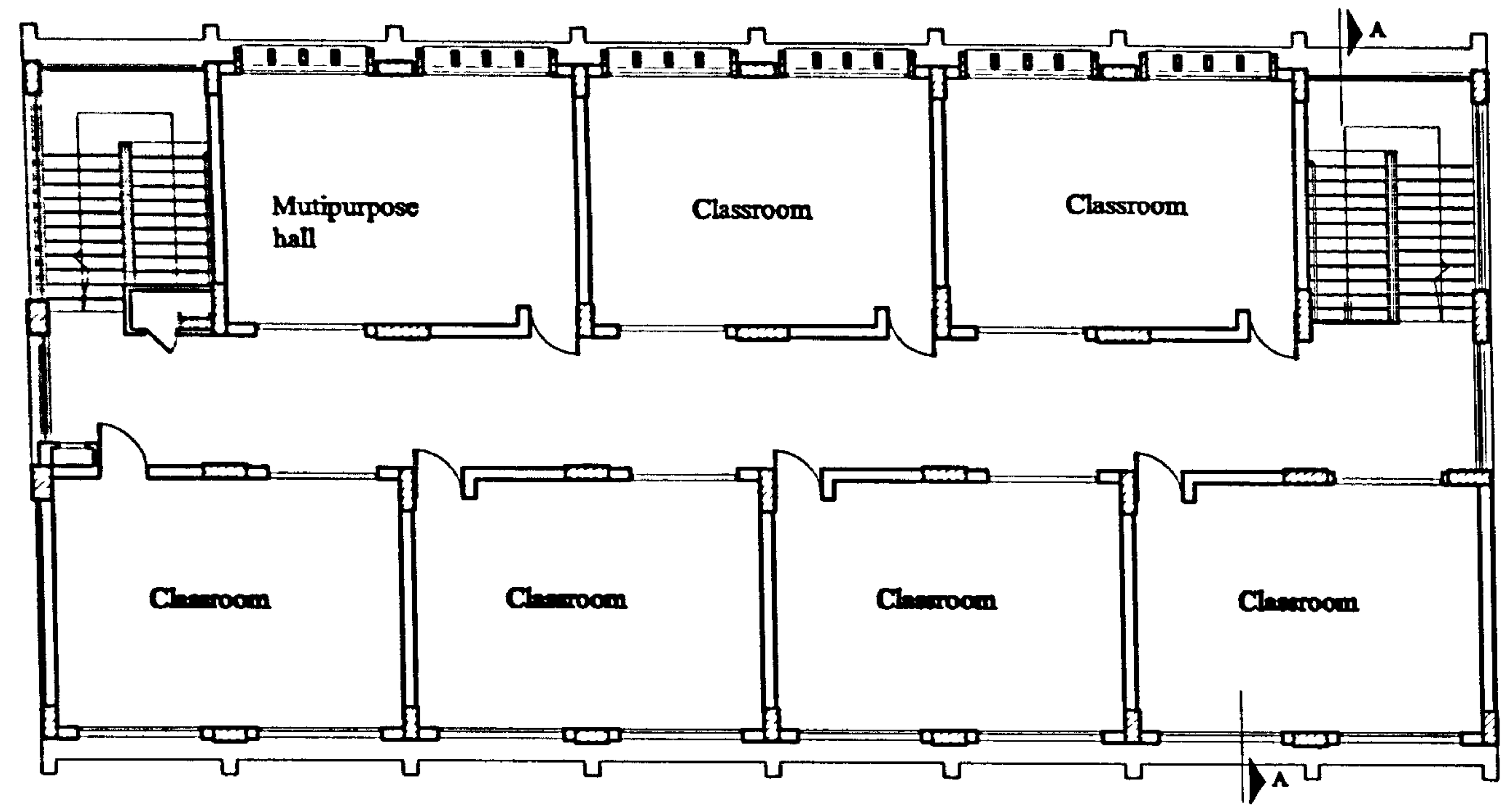


First floor

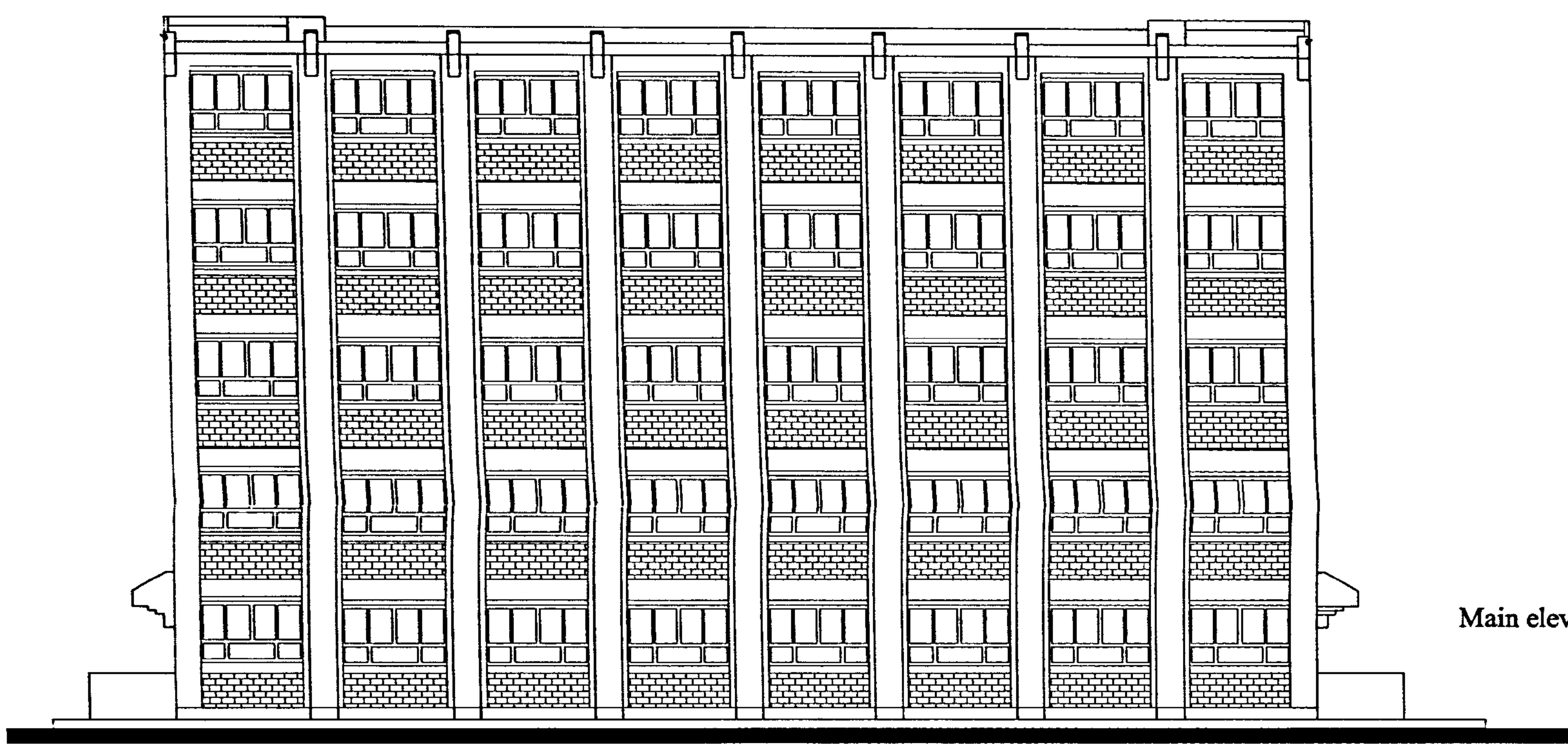


Ground floor

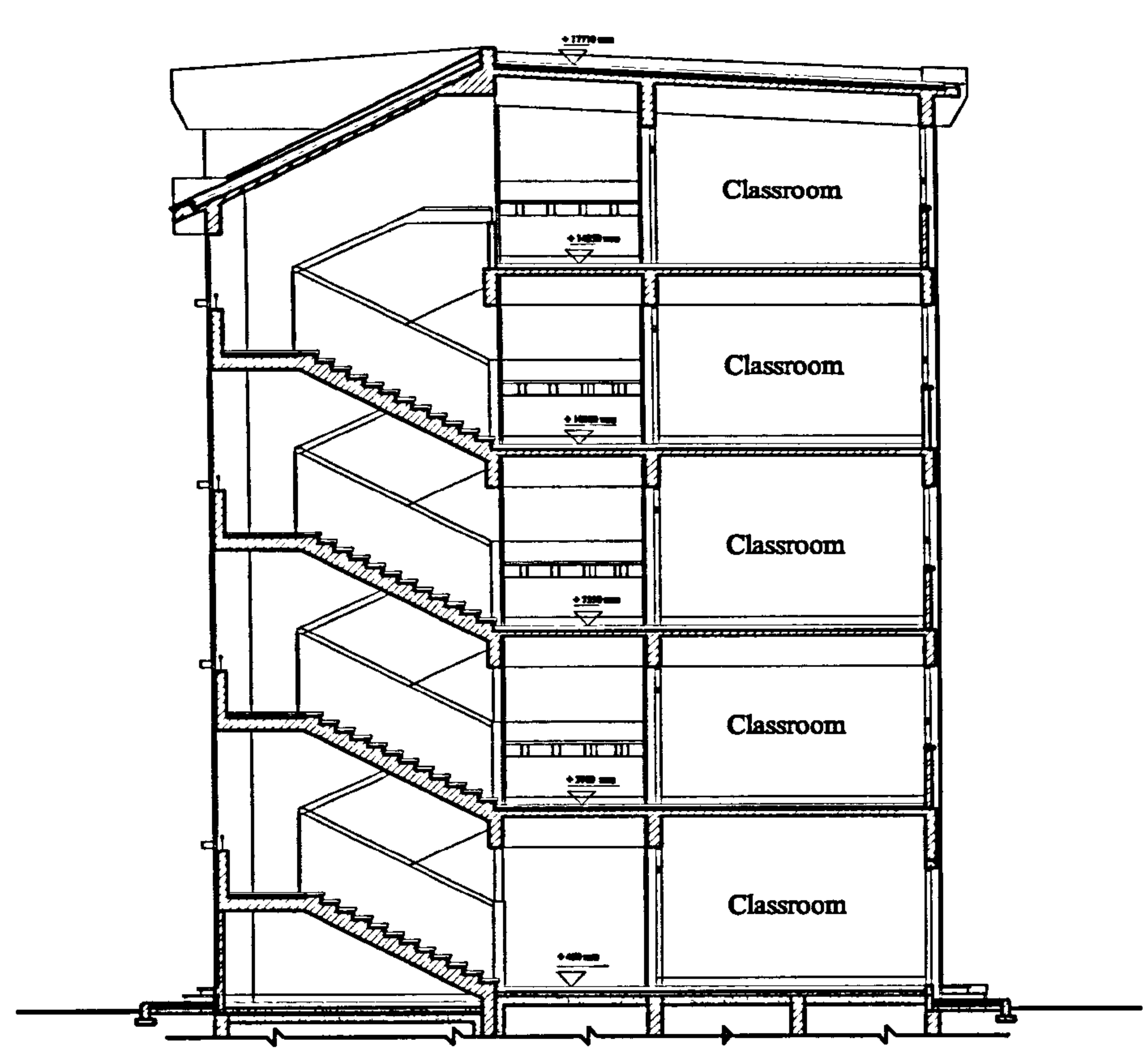
Prototype	Scale	Number of floors	References	
T18	1/200	5	Prepared by the author after the General Authority of Educational Buildings	5 - A



Fourth floor



Main elevation



Vertical section A-A

Prototype	Scale	Number of floors	References	
T18	1/200	5	Prepared by the author after the General Authority of Educational Buildings	5 - B

Appendix 6:
Interviews' results of field study two

Table 1: Interviews' results of field study two

ID	Occupants	School Name	Town	Number of Classrooms	Form (SRLF=1, DRLF=2, LF=3)	Context (Urban=1, Rural=2)	Gender	Age	Thermal Comfort	Lighting	Acoustic
1	P	Abnaa Elthora	Bani Mazar	18	2	1	M	11	1	1	1
2	P	Abnaa Elthora	Bani Mazar	18	2	1	M	9	1	0	0
3	P	Abnaa Elthora	Bani Mazar	18	2	1	F	10	1		
4	T	Abnaa Elthora	Bani Mazar	18	2	1	F	32	1	0	1
5	T	Abnaa Elthora	Bani Mazar	18	2	1	M	45	1	0	-1
6	T	Abnaa Elthora	Bani Mazar	18	2	1	M	35	1	1	1
7	P	Abou sedhm	Samalout	18	2	2	M	10	1	1	-1
8	P	Abou sedhm	Samalout	18	2	2	M	11	1	0	-1
9	P	Abou sedhm	Samalout	18	2	2	F	10	0		
10	T	Abou sedhm	Samalout	18	2	2	M	40	1	1	-1
11	T	Abou sedhm	Samalout	18	2	2	M	28	1	0	-1
12	T	Abou sedhm	Samalout	18	2	2	M	30	1		
13	P	Alabasia	ElMinya	18	2	2	M	9	1	1	0
14	P	Alabasia	ElMinya	18	2	2	F	11	1	-1	-1
15	P	Alabasia	ElMinya	18	2	2	F	11	1	0	-1
16	T	Alabasia	ElMinya	18	2	2	M	33	0	-1	-1
17	T	Alabasia	ElMinya	18	2	2	M	46	-1	-1	0
18	T	Alabasia	ElMinya	18	2	2	M	24	0		
19	P	Dahrot 2	Maghagha	18	2	2	M	10	1	0	0
20	P	Dahrot 2	Maghagha	18	2	2	M	10	0	1	-1
21	P	Dahrot 2	Maghagha	18	2	2	F	32	-1		
22	T	Dahrot 2	Maghagha	18	2	2	M	32	1	1	0
23	T	Dahrot 2	Maghagha	18	2	2	M	44	1	0	-1
24	T	Dahrot 2	Maghagha	18	2	2	F	29	0	1	0
25	P	Dahrot 3	Maghagha	12	2	2	M	8	1	0	0
26	P	Dahrot 3	Maghagha	12	2	2	M	10	1	0	1
27	P	Dahrot 3	Maghagha	12	2	2	M	10	0	1	-1
28	T	Dahrot 3	Maghagha	12	2	2	M	25	1	1	0
29	T	Dahrot 3	Maghagha	12	2	2	M	47	1	1	1
30	T	Dahrot 3	Maghagha	12	2	2	F	45	1		
31	P	Dahrot 4	Maghagha	12	2	2	M	9	1	1	-1
32	P	Dahrot 4	Maghagha	12	2	2	M	9	1	0	-1
33	P	Dahrot 4	Maghagha	12	2	2	F	10	-1		
34	T	Dahrot 4	Maghagha	12	2	2	M	36	1	1	0
35	T	Dahrot 4	Maghagha	12	2	2	M	42	1	0	0
36	T	Dahrot 4	Maghagha	12	2	2	F	33	0	1	0
37	P	Elarooba	Matay	6	1	1	M	10	0	1	1
38	P	Elarooba	Matay	6	1	1	M	9	1	1	-1
39	P	Elarooba	Matay	6	1	1	M	10	0		
40	T	Elarooba	Matay	6	1	1	M	41	1	-1	0
41	T	Elarooba	Matay	6	1	1	M	36	0	0	1
42	T	Elarooba	Matay	6	1	1	F	23	1		
43	P	Elashmonin	Malawi	12	1	2	M	10	1	0	-1
44	P	Elashmonin	Malawi	12	1	2	M	9	1	1	-1
45	P	Elashmonin	Malawi	12	1	2	F	11	0	-1	-1

46	T	Elashmonin	Malawi	12	1	2	M	29	1	1	0
47	T	Elashmonin	Malawi	12	1	2	M	49	1	1	-1
48	T	Elashmonin	Malawi	12	1	2	F	33	1		
49	P	Elgharabawi	Bani Mazar	6	2	2	M	10	1	1	0
50	P	Elgharabawi	Bani Mazar	6	2	2	M	11	1	1	0
51	P	Elgharabawi	Bani Mazar	6	2	2	F	12	1		
52	T	Elgharabawi	Bani Mazar	6	2	2	M	43	1	1	-1
53	T	Elgharabawi	Bani Mazar	6	2	2	F	32	0	1	0
54	T	Elgharabawi	Bani Mazar	6	2	2	M	38	1		
55	P	Elshaheed	ElMinya	12	3	1	M	9	1	1	1
56	P	Elshaheed	ElMinya	12	3	1	M	11	1	0	1
57	P	Elshaheed	ElMinya	12	3	1	F	12	-1		
58	T	Elshaheed	ElMinya	12	3	1	M	39	1	1	1
59	T	Elshaheed	ElMinya	12	3	1	M	28	1	1	1
60	T	Elshaheed	ElMinya	12	3	1	M	25	1		
61	P	Eltawfekia	Samalout	12	3	2	M	11	0	1	0
62	P	Eltawfekia	Samalout	12	3	2	F	11	1	1	-1
63	P	Eltawfekia	Samalout	12	3	2	M	9	0	0	-1
64	T	Eltawfekia	Samalout	12	3	2	F	26	0	1	1
65	T	Eltawfekia	Samalout	12	3	2	F	34	1	1	0
66	T	Eltawfekia	Samalout	12	3	2	M	38	-1	0	-1
67	P	Khaled Bn Elwaleed	Maghagha	18	2	2	M	11	1	1	-1
68	P	Khaled Bn Elwaleed	Maghagha	18	2	2	M	10	1	-1	-1
69	P	Khaled Bn Elwaleed	Maghagha	18	2	2	F	12	1		
70	T	Khaled Bn Elwaleed	Maghagha	18	2	2	M	43	1	1	-1
71	T	Khaled Bn Elwaleed	Maghagha	18	2	2	M	32	1	0	0
72	T	Khaled Bn Elwaleed	Maghagha	18	2	2	F	42	0		
73	P	Kolba	Malawi	6	1	2	F	11	1	1	-1
74	P	Kolba	Malawi	6	1	2	M	10	1	1	-1
75	P	Kolba	Malawi	6	1	2	M	10	1	0	-1
76	T	Kolba	Malawi	6	1	2	M	25	1	1	1
77	T	Kolba	Malawi	6	1	2	M	32	1	1	0
78	T	Kolba	Malawi	6	1	2	M	45	1	0	-1
79	P	Makosa	ElMinya	12	2	2	F	9	0	1	-1
80	P	Makosa	ElMinya	12	2	2	M	10	1	1	1
81	P	Makosa	ElMinya	12	2	2	M	11	1	1	-1
82	T	Makosa	ElMinya	12	2	2	F	29	1	0	0
83	T	Makosa	ElMinya	12	2	2	M	34	1	0	-1
84	T	Makosa	ElMinya	12	2	2	M	44	1	1	-1
85	P	Monshaa Elfekrea	Abou Korkas	12	2	1	F	7	1	1	-1
86	P	Monshaa Elfekrea	Abou Korkas	12	2	1	M	8	0	0	-1
87	P	Monshaa Elfekrea	Abou Korkas	12	2	1	M	11	1	1	0
88	T	Monshaa Elfekrea	Abou Korkas	12	2	1	M	33	1	1	-1
89	T	Monshaa Elfekrea	Abou Korkas	12	2	1	M	32	1	1	0
90	T	Monshaa Elfekrea	Abou Korkas	12	2	1	M	43	1	-1	-1
91	P	Omar Bn Elkhatab	ElMinya	6	1	1	F	7	1	1	1
92	P	Omar Bn Elkhatab	ElMinya	6	1	1	M	10	1	-1	0
93	P	Omar Bn Elkhatab	ElMinya	6	1	1	M	11	1	1	1

94	T	Omar Bn Elkhatab	ElMinya	6	1	1	F	27	1	-1	1
95	T	Omar Bn Elkhatab	ElMinya	6	1	1	M	31	1	0	1
96	T	Omar Bn Elkhatab	ElMinya	6	1	1	M	44	1	1	1
97	P	Salah Eldin	Abou Korkas	6	1	1	M	8	1	1	0
98	P	Salah Eldin	Abou Korkas	6	1	1	M	9	1	-1	-1
99	P	Salah Eldin	Abou Korkas	6	1	1	F	12	1		
100	T	Salah Eldin	Abou Korkas	6	1	1	M	35	1	-1	-1
101	T	Salah Eldin	Abou Korkas	6	1	1	M	41	1	1	-1
102	T	Salah Eldin	Abou Korkas	6	1	1	M	32	1	0	-1
103	P	Terfa Elbaharia	Samalout	12	1	2	M	9	1	1	-1
104	P	Terfa Elbaharia	Samalout	12	1	2	M	11	1	1	-1
105	P	Terfa Elbaharia	Samalout	12	1	2	F	12	1		
106	T	Terfa Elbaharia	Samalout	12	1	2	M	39	1	0	-1
107	T	Terfa Elbaharia	Samalout	12	1	2	F	32	1	-1	-1
108	T	Terfa Elbaharia	Samalout	12	1	2	M	47	[illegible]	1	0

Key for Thermal, visual and acoustic comfort		
-1	0	1
Discomfort	Neutral	Comfort

Appendix 7:
Interviews and questionnaires of field study three

University of Dundee
Dundee School of Architecture

College of Art & Design, Architecture, Engineering & Physical Sciences

DUNDEE

Questionnaire's questions for primary school's students

School: ....Code:.........................
Town:............................
Classroom location:
Floor level: ....(Centre☐ Edge☐), Orientation:......

1. Personal details
Name:.......................................
Age: 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10☐ 11☐ 12☐
Gender: Boy ☐ Girl ☐
Grade level: 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐

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2. Where you are sitting in the classroom?
Beside the window ☐ Beside the corridor wall ☐ At the centre of the classroom ☐

3. Where you prefer to sit in the classroom?
Beside the window ☐ Beside the corridor wall ☐ At the centre of the classroom ☐

4. Do you able to open and close the windows whenever you want?
Yes ☐ No ☐

5. Are the windows still opened all of the time?
Yes ☐ Most o f the time ☐ Some time ☐

6. Does the sun penetrate the classroom through the windows?
Yes ☐ Most o f the time ☐ Some time ☐

7. Does the sun penetration bother you?
Yes ☐ No ☐

8. Do you prefer to have internal curtains on the windows?
Yes ☐ No ☐

9. What kind of clothes you wear these days?
Light ☐ Medium ☐ Heavy ☐

10. Does the sun come over your seat during the day?
Yes ☐ No ☐

11. Do you feel that you want to take off some of your clothes?
Yes ☐ No ☐ to role up my sleeves ☐

12. Do you prefer if some classes to take outside the classroom?
Yes ☐ No ☐

13. When you prefer to take the classes outside?
Morning ☐ Noon ☐ Afternoon ☐

14. Do you prefer to sit in the sun area?
Yes ☐ No ☐

15. Is the classroom in general comfortable?
Yes ☐ No ☐

16. Do you prefer to wear complete sleeves or half sleeves these days?
Half sleeves ☐ Complete sleeves ☐

17. Do you prefer if your classroom provided with fans?
Yes ☐ No ☐

18. When you want these fans to work?
Morning ☐ Noon ☐ Afternoon ☐

19. How do you feel inside your classroom during the day?
(Hot 3☐ /Warm 2☐ Slightly Warm 1☐ / Neutral 0☐ / Slightly cool -1☐ Cool -2☐ / cold -3☐)

20. Does the classroom area suitable?
Yes ☐ No ☐

21. Do you prefer it different?
Bigger ☐ Smaller ☐

22. Do you open the windows on the corridor?
Yes ☐ No ☐

23. Do you close the classroom's door during the day?
Yes ☐ No ☐

University of Dundee
Dundee School of Architecture

College of Art & Design, Architecture, Engineering & Physical Sciences

DUNDEE

Questionnaire's questions for primary school's teachers

School: ....Code:.........................
Town:............................
Classroom location:
Floor level: ....(Centre☐ Edge☐), Orientation:......

1. Personal details
Name:......................................
Age:..................................
Gender: Male ☐ Female ☐

2. Are the windows still opened all of the time?
Yes ☐ Most o f the time ☐ Some time ☐

3. Does the sun penetrate the classroom through the windows?
Yes ☐ Most o f the time ☐ Some time ☐

4. Does the sun penetration bother you?
Yes ☐ No ☐

5. Are the windows still closed all of the time?
Yes ☐ Most o f the time ☐ Some time ☐

6. Do you prefer to have internal curtains on the windows?
Yes ☐ No ☐

7. What kind of clothes you wear these days?
Light ☐ Medium ☐ Heavy ☐

8. Does the sun come over your seat during the day?
Yes ☐ No ☐

9. Do you feel that you want to take off some of your clothes?
Yes ☐ No ☐ to role up my sleeves ☐

10. Do you prefer if some classes to take outside the classroom?
Yes ☐ No ☐

11. When you prefer to take the classes outside?
Morning ☐ Noon ☐ Afternoon ☐

12. Is the classroom in general comfortable?
Yes ☐ No ☐

13. Do you prefer to wear complete sleeves or half sleeves these days?
Half sleeves ☐ Complete sleeves ☐

14. Do you prefer if your classroom provided with fans?
Yes ☐ No ☐

15. When you want these fans to work?
Morning ☐ Noon ☐ Afternoon ☐

16. How do you feel inside your classroom during the day?
(Hot 3☐ /Warm 2☐/ Slightly Warm 1☐/ Neutral 0☐/ Slightly cool -1☐/ Cool -2☐/ cold -3☐)

17. Does the classroom area suitable?
Yes ☐ No ☐

18. Do you prefer it different?
Bigger ☐ Smaller ☐

19. Do you feel some times that the classroom not comfortable?
Yes ☐ No ☐

20. Do you feel that the performance of the students is affected by the temperature degree inside the classroom?
Yes ☐ No ☐

21. Do you open the windows on the corridor?
Yes ☐ No ☐

22. Do you close the classroom's door during the day?
Yes ☐ No ☐

23. Which bother the students more; the hot summer or the cold winter?
Hot climate ☐ Cold climate ☐ Both of them ☐ Neither of them ☐

24. What are the students do when they bothered from the sun penetration?
Move around ☐ Stick pieces of paper on the windows ☐
Take off some clothes ☐ Do not do any thing ☐

25. Do you prefer to work in some classes more than others?

Classroom location		Floor level	Orientation	
Centre	☐	Ground	North	☐
Corner	☐	Typical	East	☐
		Top	South	☐
			West	☐

University of Dundee
Dundee School of Architecture

College of Art & Design, Architecture, Engineering & Physical Sciences

DUNDEE

Interview's questions for primary school's students

School: ....Code:.........................
Town:............................
Classroom location:
Floor level: ....(Centre☐ Edge☐), Orientation:......

1. Personal details
Name:..
Age: ....
Gender:.......................................
Grade level: ....

2. Where you are sitting in the classroom?
3. Where you prefer to sit in the classroom?
4. And why?
5. Do you able to open and close the windows whenever you want?
6. Are the windows still opened all of the time?
7. When the window is opened and closed?
8. What you prefer?
9. Does the sun penetrate the classroom through the windows?
10. Does the sun penetration bother you?
11. Do you prefer to have internal curtains on the windows?
12. What kind of clothes you wear these days?
13. Does the sun come over your seat during the day?
14. Do you feel that you want to take off some of your clothes?
15. Do you prefer if some classes to take outside the classroom?
16. When you prefer to take the classes outside?
17. Do you prefer to sit in the sun area?
18. Is the classroom in general comfortable?
19. Do you prefer to wear complete sleeves or half sleeves these days?
20. Do you prefer if your classroom provided with fans?
21. When you want these fans to work?
22. How do you feel inside your classroom during the day?
(Hot 3☐ /Warm 2☐/ Slightly Warm 1☐ / Neutral 0☐ / Slightly cool -1☐/ Cool -2 ☐/ cold -3 ☐)
23. Does the classroom area suitable?
24. Do you prefer it different?
25. Do you open the windows on the corridor?
26. Do you close the classroom's door during the day?
27. Do you think of any thing could make the classroom much comfort?

University of Dundee
Dundee School of Architecture

College of Art & Design, Architecture, Engineering & Physical Sciences

DUNDEE

Interview's questions for primary school's teachers

School: ....Code:.........................
Town:............................
Classroom location:
Floor level: ....(Centre☐ Edge☐), Orientation:......

1. Personal details
Name:..
Age: ....
Gender:.......................................

2. Are the windows still opened all of the time?
3. When the window is opened and closed?
4. What you prefer?
5. Does the sun penetrate the classroom through the windows?
6. Does the sun penetration bother you?
7. And why?
8. Are the windows still closed all of the time?
9. Do you prefer to have internal curtains on the windows?
10. What kind of clothes you wear these days?
11. Does the sun come over your seat during the day?
12. Do you feel that you want to take off some of your clothes?
13. Do you prefer if some classes to take outside the classroom?
14. When you prefer to take the classes outside?
15. Does the classroom area suitable?
16. Do you prefer to wear complete sleeves or half sleeves these days?
17. Do you prefer if your classroom provided with fans?
18. When you want these fans to work?
19. How do you feel inside your classroom during the day?
(Hot 3☐ /Warm 2☐/ Slightly Warm 1☐ / Neutral 0☐ / Slightly cool -1☐/ Cool -2 ☐/ cold -3 ☐)
20. Does the classroom area suitable?
21. Do you prefer it different?
22. Do you feel some times that the classroom not comfortable?
23. Do you feel that the performance of the students is affected by the temperature degree inside the classroom?
24. And how do you assess that?
25. Do you open the windows on the corridor?
26. Do you close the classroom's door during the day?
27. And why?
28. Which bother the students more; the hot summer or the cold winter?
29. What are the students do when they bothered from the sun penetration?
30. Do you prefer to work in some classes more than others?
31. Do you think of any thing could make the classroom much comfort?

Appendix 8:
Interviews and questionnaires' results of field study three

SUBJECTIVE ASSESSMENT May / 2007

Questions	
1	Location
	School's name
	3 Classroom location: Floor level
	3 Classroom location: Position 4 (Edge E/Centre C)
	3 Classroom location: Orientation
	Teachers T / Students S (S 1, T 2)
	Questionnaire Q / Interview I
	Class grade (comp 7, Lab 8)
	ID
	Name
	Gender M /F
	Age
	Students' questionnaire and interviews questions
2	Student seat location (window 1 / corridor wall 2 / centre 3)
3	Where the student love to sit (window 1 / corridor wall 2 /centre 3)
4	Can you open the window whenever you want? (Yes 1/ No 2)
5	Are the windows still opened all of the time? (Yes 1 / most of the time 2 / some time 3)
6	Does the sun penetrate the classroom through the windows? (Yes 1/ sometime 2 / No 3)
7	does the sun penetration bother you? (Yes 1/ No 2)
8	Are the windows still closed all of the time? (Yes 1 / most of the time 2 / some time 3)
9	Do you prefer if there are curtains on the windows? (Yes 1/ No 2)
10	What kind of clothes you wear these days? (Light 1 / Heavy 2 / Medium 3)
11	Does the sun come over your seat during the day? (Yes 1 / No 2)
12	Do you feel that you want to take off some of your clothes? (Yes 1 / No 2 / roll up my sleeves 3)
13	Do you prefer if some classes to take outside the classroom? (Yes 1 / No 2)
14	When you prefer to take the classes outside? (Morning 1 / During the noon time 2 / After noon 3)
15	Do you prefer to sit in the sun area? (Yes 1 / No 2)
16	Does the classroom in general comfortable? (Yes 1 / No 2)
17	Do you prefer to wear complete sleeves or half sleeves these days? (Complete 1 / Half 2)
18	Do you prefer if your classroom provided with fans? (Yes 1 / No 2)
19	When you want these fans to work? (Morning 1 / During the noon time 2 / After noon 3))
20	How do you feel (Hot 3 / Warm 2 / Slightly warm 1 / Neutral 0 / Slightly cool -1 / Cool -2 / cold -3)
21	Does the classroom area suitable? (Yes 1 / No 2)
22	Do you prefer it different? (Bigger 1 / Smaller 2)
23	Do you open the windows on the corridor? (Yes 1 / No 2 / no windows on the corridor)
24	Do you close the classroom's door during the day? (Yes 1, No 2)

Belbis	Sekem	G	C	N/SW	S	Q	2	1	Amany Naser	F	9	2	3	1	2	2	2	3	1	3	2	2	1	1	2	1	1	1	3	4	1	0	0	1
		G	C	N/SW	S	Q	2	2	Esraa Elsaeed	F	9	2	2	1	3	2	2	3	1	3	2	1	1	2	2	1	1	1	2	4	1	0	0	1
		G	C	N/SW	S	Q	2	3	Bahi Sami	M	9	2	1	1	3	2	1	3	1	3	2	1	1	3	2	1	1	1	2,3	3	1	0	0	1
		G	C	N/SW	S	Q	2	4	Yousef Mohamed	M	9	2	2	1	2	2	2	3	1	2	2	2	1	2	2	1	2	1	0	5	1	0	0	2
		G	C	N/SW	S	Q	2	5	Ahmed Mostafa	M	9	3	3	1	1	1	1	3	1	1	1	3	1	1	1	1	2	1	3	4	1	0	0	1
		G	C	N/SW	S	Q	2	6	Mahmoud ElSaied	M	9	3	3	1	3	0	1	3	1	2	2	2	2	0	2	1	1	1	2	3	1	0	0	1
		G	C	N/SW	S	Q	2	7	Mohamed Ebraheem	M	9	3	2	1	3	2	2	3	1	3	2	1	1	1	0	1	1	1	2	3	1	0	0	1
		G	C	N/SW	S	Q	2	8	Abd Elrahman Amr	M	9	3	2	1	1	1	2	3	1	3	2	1	1	2	2	1	1	2	0	5	1	0	0	1
		G	C	N/SW	S	Q	2	9	Amera Ebraheem	F	9	2	3	1	3	2	2	3	1	1	2	1	1	1	2	1	1	1	2	4	1	0	0	1
		G	C	N/SW	S	Q	2	10	Ahmed Abd Elaziz	M	9	2	3	2	3	2	1	3	1	1	1	1	1	2	2	2	2	1	1,2,3	1	1	0	0	1
		G	C	N/SW	S	Q	2	11	Hala Mohamed	F	9	0	1	1	2	2	0	3	1	3	1	2	2	0	2	1	1	1	2	4	1	0	0	1
		G	C	N/SW	S	Q	2	12	Shehab ElDin	M	9	1	3	1	3	2	2	3	1	3	1	2	1	2	2	1	2	1	2,3	3	1	0	0	1
		G	C	N/SW	S	Q	2	13	Gamal Abd ElHameed	M	9	1	3	2	3	2	1	3	1	3	2	2	1	2	2	2	1	1	2	3	1	0	0	1
		G	C	N/SW	S	Q	2	14	Asmaa Gamal	F	9	1	3	1	3	2	2	3	1	3	1	2	1	1	0	1	1	1	2	4	1	0	0	1
		G	C	N/SW	S	Q	2	15	Rehab Abd ElRahman	F	9	1	3	1	3	2	1	3	1	1	2	1	1	1	2	1	2	1	2	4	1	0	0	1
		G	C	N/SW	S	Q	2	16	Abd ElMenam AlSaied	M	9	1	1	1	1	1	2	3	1	3	2	2	1	1	1	1	2	1	2	4	1	0	0	1
		G	C	N/SW	S	I	2	17	Reham Moslem	F	9	3	3	1	2	2	2	3	1	3	2	2	2	0	2	1	1	1	2	4	1	0	0	1
		G	C	N/SW	S	I	2	18	Nora Hussien	F	9	3	3	1	2	2	2	3	1	3	2	2	1	2	2	1	1	1	2,3	3	1	0	0	1
		G	C	N/SW	S	I	2	19	Maiada Hosam	F	9	3	3	1	2	2	2	3	1	3	2	2	1	2	2	1	1	2	0	3	1	0	0	1
		G	C	N/SW	S	I	2	20	Heba AlSaeed	F	9	3	3	1	2	2	2	3	1	3	2	2	1	1	2	1	1	1	2,3	4	1	0	0	1
		G	C	N/SW	S	I	2	21	Lobna Ebraheem	F	9	2	3	1	2	2	2	3	2	3	2	2	1	1	2	1	1	1	2,3	4	1	0	0	1
		G	C	N/SW	S	I	2	22	Nesreen Aaid Saleh	F	9	2	3	1	3	2	1	3	1	3	2	1	1	2	2	1	1	1	2	4	1	0	0	1
		G	C	N/SW	S	I	2	23	Khaled Mohamed	M	9	2	2	1	3	2	2	3	1	3	2	1	1	1	2	1	2	2	0	4	1	0	0	1
		G	C	N/SW	S	I	2	24	AlSaeed Mohamed	M	9	2	2	1	3	2	2	3	1	1	2	1	1	1	2	1	1	1	3	4	1	0	0	1
		1	C	SW	S	I	1	31	Sameh Hana	M	8	2	3	1	2	2	1	3	1	3	2	2	1	2	2	1	2	1	3	2	1	0	1	1
		1	C	SW	S	I	1	32	Andraw Ibraheem	M	10	1	3	1	2	2	1	3	1	3	1	1	1	2,3	2	2	2	1	2	2	2	1	1	1
		1	C	SW	S	I	1	33	Kamal Ahmed	M	7	2	2	2	1	1	2	3	1	3	2	1	1	2	2	2	2	1	2,3	2	1	0	1	1
		1	C	SW	S	I	1	34	Abd Alrahman Kamel	M	7	1	1	1	3	2	1	3	1	1	1	1	1	2	2	2	1	2	0	3	1	0	1	2
		1	C	SW	S	I	1	35	Kareem Ashraf	M	7	1	1	1	2	2	1	3	1	1	1	1	1	2	2	2	2	1	2	1	1	0	1	1
		1	C	SW	S	I	1	36	Mohamed Gamal	M	7	1	1	1	2	2	1	3	1	1	1	1	1	2	2	1	2	1	2	3	1	0	1	1
		1	C	SW	S	I	1	37	Mahmoud Salam	M	7	1	1	1	2	2	2	3	1	1	1	1	2	0	2	2	2	1	2	3	2	2	1	1
		1	C	SW	S	I	1	38	Ahmed Atef	M	7	1	1	1	2	2	1	3	1	1	1	1	2	0	2	2	2	1	2	2	2	1	1	1
		1	C	SW	S	I	1	39	Kareem Mokhtar	M	7	1	1	1	2	2	1	3	1	1	1	1	2	0	2	2	2	1	2	1	2	1	1	1
		1	C	SW	S	I	1	40	Abd Alrahman Ahmed	M	7	1	1	1	1	2	2	3	1	1	2	1	2	0	2	2	2	1	2	1	2	1	1	1

Al-Minya

Omar ebn al-Khatab

1	C	SW	S	I	1	41	Mohamed Ezat	M	7	1	1	1	2	2	2	3	1	1	1	1	2	0	2	2	2	1	2	3	1	0	1	2
1	C	SW	S	I	1	42	Aiman Mohamed	M	7	1	1	1	1	1	1	3	1	1	1	3	1	1	2	1	2	1	2	2	1	0	2	1
1	C	SW	S	I	1	43	Hassan Mostafa	M	7	1	1	1	1	2	1	3	1	1	1	1	1	2	2	1	2	1	2	1	1	1	1	1
1	C	SW	S	I	1	44	Mohamed Abd Elwahab	M	7	1	1	1	2	2	1	3	1	1	1	1	2	0	2	2	2	1	2	3	2	1	1	1
1	C	SW	S	I	1	45	Mohamed Mohei	M	7	1	1	1	2	2	1	3	1	1	2	3	1	2	2	1	2	1	2	4	2	1	2	1
1	C	SW	S	I	1	46	Ahmed Farouq	M	7	1	1	1	3	1	1	3	1	1	1	3	1	2	2	1	2	1	2	3	2	1	2	1
1	C	SW	S	I	1	47	Abd Allah Alaa	M	7	2	2	2	3	2	1	3	1	1	2	2	1	1	2	2	2	1	2	4	2	1	2	1
1	C	SW	S	I	1	48	Ahmed Hussein	M	7	1	1	1	3	1	1	3	1	1	1	3	2	0	2	1	2	1	2	2	2	1	2	1
1	C	SW	S	I	1	49	Roqia Mohamed	F	7	3	1	1	2	1	2	3	1	3	2	1	1	2	2	2	1	1	2	2	2	1	1	2
1	C	SW	S	I	1	50	Basma Gamal	F	7	3	3	2	2	2	2	3	1	3	2	1	1	3	2	1	2	1	2	3	1	0	1	2
1	C	SW	S	I	1	51	Mona Saleh	F	7	3	0	1	2	2	2	3	1	3	1	1	1	3	2	1	2	1	2,3	1	1	0	1	2
1	C	SW	S	I	1	52	Omar Hussien	M	7	1	1	1	1	1	1	3	1	1	1	3	1	1	2	1	2	1	2	2	1	0	2	1
1	C	SW	S	I	1	53	Heba Said	F	7	3	3	1	3	1	1	3	1	1	1	3	1	1	2	1	2	1	2	1	1	0	2	1
1	C	SW	S	I	1	54	Hoda Mokhtar	F	7	3	3	1	2	2	2	3	2	3	2	1	1	2,3	2	2	2	1	2,3	2	1	1	1	2
1	C	SW	S	I	1	55	Hadeer Mahmoud	F	7	1	3	1	2	1	1	3	1	1	1	1	1	2,3	2	2	2	1	2,3	2	2	1	1	2
1	C	SW	S	I	1	56	Nagat Ahmed	F	7	3	3	1	2	2	1	3	1	1	1	3	1	1	2	1	2	1	2	1	1	0	2	1
1	C	SW	S	I	1	57	Hajar Salh	F	7	3	3	1	2	2	2	3	2	3	2	1	1	2,3	2	1	2	1	2,3	1	1	0	1	2
1	C	SW	S	I	1	58	Hajar Adel	F	7	3	3	2	2	2	1	3	1	1	1	1	1	2,3	2	1	2	1	2,3	2	2	1	1	2
1	C	SW	S	I	1	59	Amena Mohamed	F	7	3	1	1	3	2	1	3	1	1	1	3	1	1	2	1	2	1	2	1	1	0	2	1
1	C	SW	S	I	1	60	Shaimaa Alaa	F	7	3	2	1	3	2	1	3	1	1	1	3	1	1	2	1	2	1	2	1	1	0	2	1
1	C	SW	S	I	1	61	Rehab Said	F	7	3	3	1	2	2	2	3	2	1	2	1	1	2,3	2	1	2	1	2,3	1	1	0	1	2
1	C	SW	S	I	1	62	Nada Alaa	F	7	3	1	1	3	1	1	3	1	1	1	3	1	1	2	1	2	1	2	1	1	0	2	1
3	C	NW	S	Q	6	67	Mohamed Kamel	M	12	2	1	2	3	3	2	3	1	1	1	1	1	3	2	0	0	2	0	2	1	0	1	1
3	C	NW	S	Q	6	68	Reham Mohamed	F	12	3	3	1	3	1	2	3	1	1	1	1	1	1	2	2	2	1	2	1	1	0	1	1
3	C	NW	S	Q	6	69	Zainab Ibraheem	F	12	3	3	1	3	1	2	3	1	1	1	1	1	1	2	2	2	1	2	1	1	0	1	1
3	C	NW	S	Q	6	70	Raafat Mosa	M	12	1	1	1	2	2	2	3	1	3	2	2	1	2	2	1	2	1	2	3	1	0	2	1
3	C	NW	S	Q	6	71	Hadeer Hamada	F	12	3	3	2	2	2	1	3	1	1	1	1	1	2	2	1	2	1	2	1	1	0	1	1
3	C	NW	S	Q	6	72	Enji Osama	F	12	3	3	1	2	1	1	3	1	1	2	1	1	2	2	1	2	1	2	1	1	0	2	1
3	C	NW	S	Q	6	73	Marina Malak	F	12	3	3	2	2	2	1	3	1	1	1	1	1	2	2	1	2	1	2	1	1	0	1	1
3	C	NW	S	Q	6	74	Yousef Amin	M	12	1	3	1	1	3	2	3	1	1	2	1	1	2	2	2	2	1	3	1	2	1	1	1
3	C	NW	S	Q	6	75	Mohamed Mady	M	12	1	1	1	2	2	1	3	1	3	1	3	1	1	1	2	0	1	2	3	2	1	1	1
3	C	NW	S	Q	6	76	Mostafa Khaled	M	12	1	1	1	1	2	1	3	1	1	2	1	1	2	2	1	1	1	2	1	1	0	1	1
3	C	NW	S	Q	6	77	Aiaa Esmaiel	F	12	3	3	1	2	3	1	3	1	1	1	3	1	1	2	1	1	1	1	4	1	0	1	1
3	C	NW	S	Q	6	78	Kareem Makhloof	M	12	2	1	1	3	1	2	2	2	1	1	1	1	3	2	1	2	1	2	1	1	0	3	1
3	C	NW	S	Q	6	79	AlHasan Hussien	M	12	2	1	1	1	1	2	3	2	1	1	1	1	3	2	1	2	1	2	1	1	0	3	1
3	C	NW	S	Q	6	80	Abanob Meshiel	M	12	2	3	1	2	2	1	3	1	1	2	1	1	3	2	1	2	1	2	1	1	0	3	1

Al-Minya

Al-lamaty

3	C	NW	S	Q	6	81	Gehad Raffat	F	12	3	3	1	1	3	2	3	2	3	2	2	1	2	2	1	1	1	2	3	1	0	2	1
3	C	NW	S	Q	6	82	Mostafa Mamdouh	M	12	2	2	1	2	2	1	3	1	1	2	1	1	2	2	1	2	1	2	4	1	0	1	1
3	C	NW	S	Q	6	83	Sami Khaled	M	12	3	1	1	1	3	1	3	2	3	2	1	1	2	2	1	2	1	2	3	1	0	2	1
3	C	NW	S	Q	6	84	Beshou Magdi	M	12	2	1	2	1	1	1	3	1	1	2	1	1	2	2	1	2	1	2	2	1	0	2	1
3	C	NW	S	Q	6	85	Esraa Gamal	F	12	3	1	2	1	3	2	3	2	1	2	1	1	2	2	1	2	1	2	3	1	0	1	1
3	C	NW	S	Q	6	86	Maha Saad	F	12	3	1	1	2	3	1	3	1	3	2	1	1	1	2	1	2	1	2	3	1	2	1	1
3	C	NW	S	Q	6	87	Hanaa Mahmoud	F	12	3	3	1	2	3	1	3	1	3	2	1	1	1	2	1	1	1	2	3	1	0	3	1
3	C	NW	S	Q	6	88	Abd Elrahman Ahmed	M	12	1	1	2	2	1	2	3	1	1	2	1	1	1	1	1	2	1	2	3	1	0	2	1
3	C	NW	S	Q	6	89	Kareem Hamdi	M	12	1	1	2	2	1	2	3	1	1	2	1	1	1	2	1	2	1	2	3	1	0	2	1
3	C	NW	S	Q	6	90	Ahmed Medhat	M	12	1	1	2	2	1	2	3	1	1	2	1	1	1	2	1	2	1	2	3	1	0	2	1
3	C	NW	S	Q	6	91	Kamel Esmaiel	M	12	1	1	1	1	3	2	3	1	1	2	1	2	0	2	1	1	1	2	3	1	0	2	1
3	C	NW	S	I	6	92	Mohamed Hassan	M	12	1	1	1	3	3	1	2	1	1	2	2	1	1	2	1	2	1	2	3	1	0	2	1
3	C	NW	S	I	6	93	Yousef Shehata	M	12	1	1	1	2	2	2	3	1	1	2	1	1	3	2	1	2	1	2	2	1	0	1	1
3	C	NW	S	I	6	94	Mahmoud Alaa	M	12	2	1	2	1	1	1	3	1	1	2	1	1	1	2	1	2	1	2	2	1	0	2	1
3	C	NW	S	I	6	95	Amjad Maher	M	12	2	2	2	3	1	2	1	3	1	1	1	1	2	2	2	2	1	2	3	1	0	2	1
3	C	NW	S	I	6	96	Fatema Mohamed	F	12	3	3	1	2	1	1	3	1	1	2	1	1	2	2	1	2	1	2	1	1	0	2	1
3	C	NW	S	I	6	97	0	F	12	1	1	1	1	3	1	3	2	1	2	1	1	2	2	1	2	1	3	1	1	0	1	1
3	C	NW	S	I	6	98	0	F	12	1	1	1	3	3	2	3	1	1	2	1	1	3	2	1	2	1	1	1	1	0	1	1
3	C	NW	S	I	6	99	Sali Mamdouh	F	12	3	3	1	3	1	2	3	1	1	1	1	1	2	2	2	2	1	2	1	1	0	1	1
3	E	SE	S	Q	5	100	Mena Jousef	M	11	2	2	1	2	2	1	3	2	3	2	1	2	0	2	1	2	1	2	3	1	0	1	1
3	E	SE	S	Q	5	101	Omar Esmaiel	M	11	2	1	1	1	1	1	3	2	2	1	1	1	2	2	2	2	1	2	1	2	1	3	2
3	E	SE	S	Q	5	102	Fathi Mohamed	M	12	0	1	2	1	1	1	3	1	1	2	1	1	3	1	1	1	1	1	4	1	0	1	1
3	E	SE	S	Q	5	103	Nourhan Gamal	F	11	2	2	2	2	2	2	3	1	1	2	1	1	2	1	1	2	1	2	4	1	0	1	1
3	E	SE	S	Q	5	104	Abanoub Helmy	M	12	2	2	2	2	2	1	3	1	1	2	1	1	2	1	1	2	1	2	3	2	1	1	1
3	E	SE	S	Q	5	105	Marout Tobia	M	11	1	1	2	2	1	2	3	1	1	2	2	1	3	2	2	2	1	2	3	1	0	1	1
3	E	SE	S	Q	5	106	Jousef Malak	M	11	1	1	2	2	1	1	3	1	1	1	1	1	1	2	1	2	1	1	4	1	0	1	1
3	E	SE	S	Q	5	107	Salsabil Ashraf	M	11	3	1	2	2	3	2	3	1	1	2	1	1	2	1	2	2	1	2	1	2	1	1	1
3	E	SE	S	Q	5	108	Aia Ramadan	F	11	3	3	2	3	1	2	2	1	3	1	1	2	0	2	1	2	1	2	0	1	0	3	1
3	E	SE	S	Q	5	109	Ahmed Mahmoud	M	11	2	2	2	3	1	1	2	1	1	2	3	1	3	1	1	2	1	3	3	1	0	1	1
3	E	SE	S	Q	5	110	Mostafa Dosoki	M	11	2	2	2	1	1	1	3	1	1	1	1	1	2	2	2	2	1	2	1	2	1	1	2
3	E	SE	S	Q	5	111	Marina Adel	F	10	3	3	1	3	2	1	3	1	3	1	1	1	2	2	2	2	1	2	3	1	0	1	1
3	E	SE	S	Q	5	112	Mariet Boutros	F	10	3	3	1	3	2	1	3	1	3	1	1	1	2	2	2	2	1	2	3	2	1	1	1
3	E	SE	S	Q	5	113	Ahmed Hani	M	11	2	2	1	2	1	1	3	1	1	2	1	1	0	2	1	1	1	1	2	1	0	2	1
3	E	SE	S	Q	5	114	Nashwa Mohamed	F	11	3	3	2	3	1	2	3	2	3	1	1	2	0	2	2	2	1	2	1	1	0	3	1
3	E	SE	S	I	5	115	Nermin Alaa	F	12	3	3	1	3	3	1	3	1	3	1	1	1	1	1	2	2	1	1	1	2	1	1	2
3	E	SE	S	I	5	116	Ahmed Osam	M	12	3	2	1	3	1	1	3	1	3	1	1	1	2	2	2	2	1	2	1	2	1	1	2
3	E	SE	S	I	5	117	Ahmed Saleh	M	12	1	2	1	3	1	1	3	1	3	1	1	1	2	2	2	2	1	2	1	2	1	1	2

Al-Minya		3	E	SE	S	I	5	118	Kareem Sharkawi	M	11	1	1	1	1	1	1	3	1	1	0	1	1	0	2	1	2	1	1	3	1	0	1	1
		3		SE	S	I	5	119	Ahmed Mohameed	M	11	1	1	1	3	1	1	2	1	1	1	1	1	0	2	1	2	1	1	2	2	1	1	1
	Al-Shaheed	1	C	N	S	Q	7	131	Khiri Rabeea	M	12	3	3	1	3	0	1	3	1	3	1	1	1	0	2	2	2	1	3	2	2	1	3	1
		1	C	N	S	Q	7	132	Abd Elrahaman Fathi	M	9	2	3	1	1	1	1	3	2	1	2	1	2	0	2	1	1	1	3	4	1	0	1	1
		1	C	N	S	Q	7	133	Aiman Alaa Abdou	M	10	2	3	1	1	1	1	3	2	1	1	1	2	0	2	1	1	1	3	4	1	0	1	1
		1	C	N	S	Q	7	134	Marwa Reda	F	9	3	3	1	1	3	2	3	2	1	2	1	1	3	2	2	2	1	2	1	2	1	1	1
		1	C	N	S	Q	7	135	Aia Kamal	F	9	3	3	1	3	1,3	2	3	2	1	2	1	1	3	2	2	2	1	2	1	2	2	1	1
		1	C	N	S	Q	7	136	Ahmed Saad	M	9	1	1	1	1,3	1	2	3	1	1	2	1	1	0	1	0	0	0	0	1	0	0	0	2
		1	C	N	S	Q	7	137	Mona Naser Taha	F	9	3	3	1		3	2	3	2	1	2	1	2	0	1	1	1	1	2	3	2	1	1	1
		1	C	N	S	Q	7	138	Asmaa Adel	F	9	3	3	1	1	3	2	3	2	1	2	1	2	0	2	1	1	1	2	4	1	0	1	1
		1	C	N	S	Q	7	139	Nada Aly	F	8	3	3	1	1	3	2	3	2	1	2	1	2	0	1	1	1	1	2	3	2	1	1	1
		1	C	N	S	Q	7	140	Menat Allah Mohamed	F	9	3	3	2	2	3	1	3	1	1	2	3	2	0	2	2	1	1	1	1	1	0	2	1
		1	C	N	S	Q	7	141	Mona Saber	F	8	3	3	1	2,3	3	1	3	1	1	2	1	1	3	2	2	2	1	1	1	2	1	2	2
		1	C	N	S	Q	7	142	Hend Hussein	F	9	1,3	3	1	3	1,3	1	3	1	1	2	1	1	3	2	2	2	1	1	1	2	1	2	2
		1	C	N	S	Q	7	143	Hajer Ahmed	F	9	1	3	1	3	3	2	3	2	1	2	2	1	3	2	1	2	1	2	1	1	0	3	1
		1	C	N	S	Q	7	144	Omar Hassan	M	12	3	3	1,2	3		2	1	1	1	1,2	1,2	1	0	0	2			2	1	1	0	1	1
		1	C	N	S	Q	7	145	Aia Saaid	F	9	1	3	1	3	1,3	1	3	1	1	2	1	1	2	2	2	1	1	1	1	2	1	2	2
		1	C	N	S	Q	7	146	Amina Mahmoud	F	9	1	3	1	3	3	2	3	2	1	2	2	1	3	2	1	2	1	2	1	1	0	3	1
		1	C	N	S	Q	7	147	Abd Elrahman Mahmoud	M	12	3	3	1	3	3	0	3	1	1	1	3	1	0	1	1	2	1	1	4	1	0	1	1
		1	C	N	S	Q	7	148	Sondos Yauhia	F	9	3	1	1	1	2	2	3	1	1	1	2	1	2	1	1	2	1	2	1	1	0	1	1
		1	C	N	S	Q	7	149	Amena Ragab	F	9	3	3	1	3	3	2	3	2	1	2	2	1	3	2		1	1	1	1	2	1	2	2
		1	C	N	S	Q	7	150	Samar Gamal	F	9	3	1	1	1	2	2	3	1	1	1	2	1	3	1	1,2	1	1	1	1	2	1	2	2
		1	C	N	S	Q	7	151	Shaimaa Habeeb	F	9	1,2																						
		1	C	N	S	Q	7	152	Eman Gamal	F	9	2,3	2	1,2	1	1	1	1	1	1	1	1	1	0	2	1	2	1	1	1	1	1	1	1
		1	C	N	S	Q	7	153	Ahmed Magdi	M	9	1	1	2	2	2	2	2	2	1	2	2	1	0	1		2		2	1	1	0	1	1
		1	C	N	S	Q	7	154	Alaa	M	12	2	3	1	2	2	2	2	0	2	2	1	1	3	1	1	2	1	2	3	2	2		2
		1	C	N	S	Q	7	155	Abd Elrahman Hassan	M	12	2	2	1	2	3	2	2	1	2	2	1	1	3	1		2		1	3	1	0	1	2
		1	C	N	S	Q	7	156	Aly Shaaban	M	12	3	3	1	1	1	0	0	1	0	0	1	1	0	1	2	2	1	3	3	1	2	1	1
		1	C	N	S	Q	7	157	Nourhan Hassan	F	9	3	3	1	1	1	1	3	1	1	1	3	2	0	1	2	1	1	3	4	1	0	1	2
		1	C	N	S	Q	7	158	Hend Kamal	F	9	3	3	1	3	1	2	1	2	1	1	1	1	0	2	1	1	1	1	1	1	0	1	1
		1	C	N	S	Q	7	159	Walaa Abd Elaziz	F	8	3	3	1	2	1	2	3	1	1	1	3	2	0	1	1	1	1	1	2	1	0	1	1
		1	C	N	S	Q	7	160	Nermin Reda	F	9	3	3	1	1	3	2	3	2	1	1	2	1	2	1	1	2	1	2	1	1	0	1	1
		1	C	N	S	I	7	161	Hend Osman	F	10	1	3	1	2	2	1	3	1	3	1	2	1	2	2	2	1	1	2	3	2	1	1	1
		1	C	N	S	I	7	162	Mostafa Fadl	M	10	3	3	1	3	3	1	3	1	3	2	2	0	1	1	1	1	2	0	5	1	0	1	1
		1	C	N	S	I	7	163	Shaaban Hassan	M	9	3	3	1	2	3	1	3	1	3	2	0	2	0	1	1	2	1	3	7	2	2	1	1
		1	C	N	S	I	7	164	Gehad Fathi	F	9	2	2	1	1	1	2	3	1	3	2	1	2	0	2	1	1	1	1	4	1	0	1	1
		1	C	N	S	I	7	165	Ahmed Taha	M	10	3	3	1	1	1	1	3	2	1	2	1	2	0	2	1	1	1	3	4	1	0	1	1

1	C	N	S	I	7	166	Islam Adel	M		2		1	3	1	2	1	1	3	2	1	2	0	2		1	1	1	4	1	0	3	2
1	C	N	S	I	7	167	Rahma Alaa	F	10	2	2	1	1	1	2	3	1	3	2	1	2	0	2	1	1	1	3	4	1	0	1	1
1	C	N	S	I	7	168	Nourhan Ahmed	F	9	1,3	1,3	2	1,3	1	2	2	1	1	2	1	1	3	2	2	2	1	2	1	2	1	1	1
1	C	N	S	I	7	169	Mohamed Habashi	M	9	1	1	1	1	3	1	2	3	1	2	2	1	0	1	2	2	1	2	3	1	0	3	1
G	C	W	S	Q	8	170		M	10	1	2	1	1	1	1	3	1	3	1	1	1	2	2	2	2	1	2	1	2	1	1	1
G	C	W	S	Q	8	171	Ahmed Khalil	M	12	2	2	1	1	1	1	3	2	3	2	1	2	0	2	2	2	1	2	2	1	0	1	1
G	C	W	S	Q	8	172	Mohamed Ali	M	11	1	2	1	1	1	1	3	1	3	2	1	1	3	2	2	2	1	2,3	1	1	0	1	1
G	C	W	S	Q	8	173	Hamdi Ali	M	10	3	2	1	1	1	1	3	1	1	1	1	1	1	2	2	2	1	2	2	2	1	1	1
G	C	W	S	Q	8	174	Salah Ibraheem	M	12	2	3	1	2	1	2	3	2	3	2	3	1	3	2	2	2	1	2	3	1	0	1	1
G	C	W	S	Q	8	175	Naser Hussien	M	12	1	2	1	2	1	1	3	1	1	1	1	1	2,3	2	2	2	1	1,2,3	1	2	1	1	1
G	C	W	S	Q	8	176	Eihab Botrus	M	11	2	2	1	1	2	1	3	1	3	2	3	1	2	2	2	2	1	1,2,3	3	1	0	1	1
G	C	W	S	Q	8	177	Salwa Atia	F	11	1	3	1	2	2	1	3	1	1	1	1	1	3	2	2	1	1	2	2	2	1	1	1
G	C	W	S	Q	8	178	Ishaq Yousef	M	11	2	3	1	2	2	2	3	1	3	2	2	1	2	2	1	2	1	2	3	1	0	1	1
G	C	W	S	Q	8	179	Ahmed Ebraheem	M	11	3	3	1	2	2	2	3	2	1	2	3	1	2	2	1	2	1	2	4	1	0	1	1
G	C	W	S	Q	8	180	Salah Hamdi	M	10	3	2	1	2	2	1	3	1	3	1	1	1	3	2	2	2	1	2	2	1	0	1	1
G	C	W	S	Q	8	181	Ahmed Mohamed	M	11	3	2	1	2	2	1	3	1	1	1	1	2	0	2	2	2	1	2,3	2	2	1	1	1
G	C	W	S	Q	8	182	Mohamed Kamal	M	11	2	3	1	2	2	1	3	1	1	2	1	1	3	2	2	2	1	2	3	1	0	1	1
G	C	W	S	Q	8	183	Laila Aly	F	12	1	2	1	2	2	1	3	1	3	1	2	1	2,3	2	2	0	1	2,3	1	2	1	1	1
G	C	W	S	Q	8	184	Reda Mohamed	M	11	1	3	1	2	2	1	3	1	3	1	3	2	0	2	2	2	1	2	2	1	0	1	1
G	C	W	S	Q	8	185	Ahmed Reda	M	11	2	3	1	2	2	1	3	1	3	2	2	1	2	2	1	2	1	2,3	4	1	0	1	1
G	C	W	S	Q	8	186	Hanna Abd Elrahman	F	10	3	3	1	2	2	2	3	1	3	2	1	1	2,3	2	2	1	1	2	4	2	1	1	1
G	C	W	S	Q	8	187	Hend Mohamed	F	11	1	2	1	2	2	1	3	1	3	1	1	1	2,3	2	1	2	1	2	2	1	0	1	1
G	C	W	S	Q	8	188	Abd Elrahman Ahmed	M	10	2	3	1	2	2	2	3	1	1	2	2	1	3	2	1	2	1	2,3	3	2	1	1	1
G	C	W	S	Q	8	189	Abd Allah Mohamed	M	11	3	0	1	2	2	2	3	1	1	2	2	1	2	2	1	2	1	2,3	4	1	0	1	1
G	C	W	S	I	8	190	Hassan Mahmoud	M	10	2	2	1	2	2	2	3	1	1	2	1	1	2,3	2	1	2	1	2,3	3	1	0	1	1
G	C	W	S	I	8	191	Ahmed Hassan	M	11	1	2	1	2	2	1	3	1	1	1	1	1	3	2	2	2	1	2,3	2	2	1	1	1
G	C	W	S	I	8	192	Salwa Ahmed	F	11	1	2	1	2	2	1	3	1	1	1	2	1	2	2	2	1	1	2,3	2	1	0	1	1

Questions		
		Location
1		School's name
		Teachers T / Students S
		Questionnaire Q / Interview I
		ID
		Name
		Gender M /F
		Age
2	Teachers' questionnair and interview questions	Are the windows still opened all of the time? (Yes 1 / most of the time 2 / some time 3)
3		Does the sun penetrate the classroom through the windows? (Yes 1/ sometime 2 / No 3)
4		does the sun penetration bother you? (Yes 1/ No 2)
5		Are the windows still closed all of the time? (Yes 1 / most of the time 2 / some time 3)
6		Do you prefer if there are curtains on the windows? (Yes 1/ No 2)
7		What kind of clothes you wear these days? (Light 1 / Heavy 2 / Medium 3)
8		Does the sun come over your seat during the day? (Yes 1 / No 2)
9		Do you feel that you want to take off some of your clothes? (Yes 1 / No 2 / to roll up my sleeves 3)
10		Do you prefer if some classes to take outside the classroom? (Yes 1 / No 2)
11		When you prefer to take the classes outside? (Morning 1 / During the noon time 2 / After noon 3)
12		Does the classroom in general comfortable? (Yes 1 / No 2)
13		Do you prefer to wear a complete sleeves or half sleeves these days? (Complete 1 / Half 2)
14		Do you prefer if your classroom provided with fans? (Yes 1 / No 2)
15		When you want these fans to work? (Morning 1 / During the noon time 2 / After noon 3))
16		How do you feel ? (hot 3 / warm2 / Slightly Warm 1 / Neutral 0 / Slightly cool -1 / cool -2 / cold -3)
17		Does the classroom area suitable? (Yes 1 / No 2)
18		Do you prefer it different? (Bigger 1 / Smaller 2)
19		Do you feel some times that the classroom not comfortable? (Yes 1 / No 2)
20		Do you feel that the performance of the students is affected by the temperature degree inside the classroom? (Yes 1 /No 2)
21		Do you open the windows on the corridor? (Yes 1 / No 2 / no windows on the corridor)
22		Do you close the classroom's door during the day? (yes 1, No 2)
23		Which bother the students more; the hot summer or the cold winter? (the hot summer 1 /The cold winter 2 / Both 3 / non of them 4)
24		What are the students do when they bothered from the sun penetration? (Move around 1 / stick some papers on the windows 2 / Nothing 3 / Take off some of their clothes 4)
25	Do you prefer to	For the direction (North 1 / East 2 / South 3 / West 4)
		For the floor levels (Ground 1 / Middle 2 / Top 3)
		For the classroom osition (Middle 1 / Edge 2)

Belbis	Sekem	T	Q	25	Mohamed Anour	M	25	3	1	2	0	2	3	2	3	1	2	1	1	2	0	4	1	0	2	1	3	1	1	1	0	3	0
		T	Q	26	Mohamed Hasona	M	32	2	3	2	3	2	3	2	2	1	3	1	1	2	0	4	1	0	2	1	3	1	1	1	4	1	1
		T	Q	27	Hosam Hafez	M	36	1	2	2	0	1	3	2	3	2	0	0	1	1	1	2	2	1	0	2	3	1	4	2	1,2,3,4	1,2,3	1,2
		T	I	28	Ursla Feltas	F	40	2	1	2	3	2	1	2	2	1	2,3	1	2	2	0	3	1	0	1	1	3	1	1	1	1	1	1
		T	I	29	Gamal	M	50	2	2	2	3	2	3	2	2	1	2,3	1	2	2	0	4	1	0	2	1	3	1	1	1	1,2	1	1,2
		T	I	30	Salem ElMasry	M	40	2	2	2	3	2	3	2	3	2	0	1	1	1	2	4	1	0	2	1	3	1	3	2	1	2	1
Al-Minya	Omar ebn al-	T	Q	64	Mona Ragab	F	38	1	1	1	3	2	1	1	1	1	2	2	2	1	2	1	2	1	1	1	1	1	3	2	4	1	1
		T	Q	65	0	F	0	1	1	1	3	2	3	1	1	1	2,3	2	2	1	2,3	2	2	1	1	1	1	1	3	1,2	2	2	1
		T	Q	66	0	F	0	2	1	3	3	1	1	1	1	1	2,3	2	2	1	2,3	1	2	1	1	1	1	1	3	2,4	1	2	1
Al-Minya	Al-lamaty	T	Q	120	Om Gerges	F	54	1	1	2	3	0	3	2	2	2	0	1	1	2	0	4	1	0	2	1	1	1	1	1,2	1,2	0	0
		T	Q	121	Hanan Kamel	F	35	2	2	1	3	1	3	1	1	2	0	1	2	1	2	3	1	0	1	1	1	1	3	2	1	1	
		T	Q	122	Sabah Saied	F	43	1,2	2	1	3	1	3	1	1	2	0	1	2	1	2	3	1	0	1	1	1	1	3	2	1	0	0
		T	Q	123	Laila Mortada	F	48	2	2	1	3	1	3	1	1	2	0	1	1	1	2	4	2	1	1	1	1	1	1	1	1	2	2
		T	Q	124	Hana Badran	F	48	3	2	1	1	1	3	0	1	1	1	1	1	1	2	3	1	0	1	1	1	1	3	2	2	2	1
		T	Q	125	Amal	F	45	1	2	2	3	1	3	2	3	1	2	1	1	1	2	3	1	0	1	1	1	1	1	2	0	0	0
		T	Q	126	Sami Georg	M	41	2	1	2	3	2	1	2	3	1	1	1	2	1	3	3	1	0	2	1	2	1	1	2	1	2	2
		T	Q	127	Basem Salah	M		1	1	1	3	1	3	1	3	1	2	1	2	1	2	3	1	0	1	1	2	1	3	1	1	1	1
		T	I	128	Shehata Fahmi	M	45	2	2	1	3	1	3	1	3	1	3	2	2	1	2,3	3	2	1	1	1	1	1	3	1,2	1	2	1
		T	I	129	Mohamed Farouq	M	35	1	2	1	3	1	3	1	3	1	2	2	2	1	2,3	3	2	1	1	1	1	1	3	1,2,3	2	2	1
		T	I	130	Magdi Ezat	M	34	2	2	2	3	1	1	2	3	2	0	1	2	1	2,3	3	1	0	1	1	1	2	3	2,4	1	2	2
Al-Minya	Al-Shaheed	T	Q	193	Salama	M	45	2	2	1	3	1	1	1	1	1	2,3	2	2	1	2,3	3	2	1	1	1	1	1	3	1,2,4	1,2	2	1
		T	Q	194	School headteacher	F	50	2	2	2	3	1	3	2	2	1	3	2	1	1	2,3	3	2	1	1	1	1	1	3	1,2,4	1,2	1,2	1
		T	Q	195	Heba Mohamed	F	31	1	2	2	3	2	1	2	2	2	0	1	1	1	2	2	2	1	1	1	1	1	1	1,4	0	0	0
		T	Q	196	Afaf Louse	F	27	2	2	2	3	1	3	2	2	2	0	1	1	1	2	3	1	0	2	1	1	1	1	1	0	0	0
		T	Q	197	Amani Fouad	F	30	1	1	2	3	1	3	2	2	2	0	1	1	1	2	3	1	0	1	1	1	1	1	1	0	0	0
		T	Q	198	Mona Gamal	F	32	2	2	2	0	1	3	2	2	2	0	1	1	1	2	3	1	0	2	1	1	1	1	2	0	0	0
		T	I	199	Amal	F	35	2	0	2	3	1,2	3	2	2	1	1	1	1	1	2	3	1	0	1	1	1	1	3	2	4	2	1
		T	I	200	Aml Abd Elqader	F	35	1	2	2	3	2	3	2	2	1	1	1	1	1	2	4	2	1	1	1	1	1	3	2	4	2	1

SUBJECTIVE ASSESSMENT May / 2007

Questions			Item
1			Location
1			School's name
1	3 Classroom location		Floor level
1	3 Classroom location		Position 4 (Edge E/Centre C)
1	3 Classroom location		Orientation
1			Teachers T / Students S (S 1, T 2)
1			Questionnaire Q / Interview I
1			Class grade (comp 7, Lab 8)
1			ID
1			Name
1			Gender M /F
1			Age
2	Students' questionnaire and interviews questions		Student seat location (window 1 / corridor wall 2 / centre 3)
3			Where the student love to sit (window 1 / corridor wall 2 /centre 3)
4			Can you open the window whenever you want? (Yes 1/ No 2)
5			Are the windows still opened all of the time? (Yes 1 / most of the time 2 / some time 3)
6			Does the sun penetrate the classroom through the windows? (Yes 1/ sometime 2 / No 3)
7			does the sun penetration bother you? (Yes 1/ No 2)
8			Are the windows still closed all of the time? (Yes 1 / most of the time 2 / some time 3)
9			Do you prefer if there are curtains on the windows? (Yes 1/ No 2)
10			What kind of clothes you wear these days? (Light 1 / Heavy 2 / Medium 3)
11			Does the sun come over your seat during the day? (Yes 1 / No 2)
12			Do you feel that you want to take off some of your clothes? (Yes 1 / No 2 / roll up my sleeves 3)
13			Do you prefer if some classes to take outside the classroom? (Yes 1 / No 2)
14			When you prefer to take the classes outside? (Morning 1 / During the noon time 2 / After noon 3)
15			Do you prefer to sit in the sun area? (Yes 1 / No 2)
16			Does the classroom in general comfortable? (Yes 1 / No 2)
17			Do you prefer to wear complete sleeves or half sleeves these days? (Complete 1 / Half 2)
18			Do you prefer if your classroom provided with fans? (Yes 1 / No 2)
19			When you want these fans to work? (Morning 1 / During the noon time 2 / After noon 3))
20			How do you feel (Hot 3 /Warm 2 / Slightly warm 1 / Neutral 0 / Slightly cool -1 / Cool -2 / cold -3)
21			Does the classroom area suitable? (Yes 1 / No 2)
22			Do you prefer it different? (Bigger 1 / Smaller 2)
23			Do you open the windows on the corridor? (Yes 1 / No 2 / no windows on the corridor)
24			Do you close the classroom's door during the day? (Yes 1, No 2)

Belbis	Sekem	G	C	N / SW	S	Q	2	1	Amany Naser	F	9	2	3	1	2	2	2	3	1	3	2	2	1	1	2	1	1	1	3	4	1	0	0	1
		G	C	N / SW	S	Q	2	2	Esraa Elsaeed	F	9	2	2	1	3	2	2	3	1	3	2	1	1	2	2	1	1	1	2	4	1	0	0	1
		G	C	N / SW	S	Q	2	3	Bahi Sami	M	9	2	1	1	3	2	1	3	1	3	2	1	1	3	2	1	1	1	2,3	3	1	0	0	1
		G	C	N / SW	S	Q	2	4	Yousef Mohamed	M	9	2	2	1	2	2	2	3	1	2	2	2	1	2	2	1	2	1	0	5	1	0	0	2
		G	C	N / SW	S	Q	2	5	Ahmed Mostafa	M	9	3	3	1	1	1	1	3	1	1	1	3	1	1	1	1	2	1	3	4	1	0	0	1
		G	C	N / SW	S	Q	2	6	Mahmoud ElSaied	M	9	3	3	1	3	0	1	3	1	2	2	2	2	0	2	1	1	1	2	3	1	0	0	1
		G	C	N / SW	S	Q	2	7	Mohamed Ebraheem	M	9	3	2	1	3	2	2	3	1	3	2	1	1	1	0	1	1	1	2	3	1	0	0	1
		G	C	N / SW	S	Q	2	8	Abd Elrahman Amr	M	9	3	2	1	1	1	2	3	1	3	2	1	1	2	2	1	1	2	0	5	1	0	0	1
		G	C	N / SW	S	Q	2	9	Amera Ebraheem	F	9	2	3	1	3	2	2	3	1	1	2	1	1	1	2	1	1	1	2	4	1	0	0	1
		G	C	N / SW	S	Q	2	10	Ahmed Abd Elaziz	M	9	2	3	2	3	2	1	3	1	1	1	1	1	2	2	2	2	1	1,2,3	1	1	0	0	1
		G	C	N / SW	S	Q	2	11	Hala Mohamed	F	9	0	1	1	2	2	0	3	1	3	1	2	2	0	2	1	1	1	2	4	1	0	0	1
		G	C	N / SW	S	Q	2	12	Shehab ElDin	M	9	1	3	1	3	2	2	3	1	3	1	2	1	2	2	1	2	1	2,3	3	1	0	0	1
		G	C	N / SW	S	Q	2	13	Gamal Abd ElHameed	M	9	1	3	2	3	2	1	3	1	3	2	2	1	2	2	2	1	1	2	3	1	0	0	1
		G	C	N / SW	S	Q	2	14	Asmaa Gamal	F	9	1	3	1	3	2	2	3	1	3	1	2	1	1	0	1	1	1	2	4	1	0	0	1
		G	C	N / SW	S	Q	2	15	Rehab Abd ElRahman	F	9	1	3	1	3	2	1	3	1	1	2	1	1	1	2	1	2	1	2	4	1	0	0	1
		G	C	N / SW	S	Q	2	16	Abd ElMenam AlSaied	M	9	1	1	1	1	1	2	3	1	3	2	2	1	1	1	1	2	1	2	4	1	0	0	1
		G	C	N / SW	S	I	2	17	Reham Moslem	F	9	3	3	1	2	2	2	3	1	3	2	2	2	0	2	1	1	1	2	4	1	0	0	1
		G	C	N / SW	S	I	2	18	Nora Hussien	F	9	3	3	1	2	2	2	3	1	3	2	2	1	2	2	1	1	1	2,3	3	1	0	0	1
		G	C	N / SW	S	I	2	19	Maiada Hosam	F	9	3	3	1	2	2	2	3	1	3	2	2	1	2	2	1	1	2	0	3	1	0	0	1
		G	C	N / SW	S	I	2	20	Heba AlSaeed	F	9	3	3	1	2	2	2	3	1	3	2	2	1	1	2	1	1	1	2,3	4	1	0	0	1
		G	C	N / SW	S	I	2	21	Lobna Ebraheem	F	9	2	3	1	2	2	2	3	2	3	2	2	1	1	2	1	1	1	2,3	4	1	0	0	1
		G	C	N / SW	S	I	2	22	Nesreen Aaid Saleh	F	9	2	3	1	3	2	1	3	1	3	2	1	1	2	2	1	1	1	2	4	1	0	0	1
		G	C	N / SW	S	I	2	23	Khaled Mohamed	M	9	2	2	1	3	2	2	3	1	3	2	1	1	1	2	1	2	2	0	4	1	0	0	1
		G	C	N / SW	S	I	2	24	AlSaeed Mohamed	M	9	2	2	1	3	2	2	3	1	1	2	1	1	1	2	1	1	1	3	4	1	0	0	1
		1	C	SW	S	I	1	31	Sameh Hana	M	8	2	3	1	2	2	1	3	1	3	2	2	1	2	2	1	2	1	3	2	1	0	1	1
		1	C	SW	S	I	1	32	Andraw Ibraheem	M	10	1	3	1	2	2	1	3	1	3	1	1	1	2,3	2	2	2	1	2	2	2	1	1	1
		1	C	SW	S	I	1	33	Kamal Ahmed	M	7	2	2	2	1	1	2	3	1	3	2	1	1	2	2	2	2	1	2,3	2	1	0	1	1
		1	C	SW	S	I	1	34	Abd Alrahman Kamel	M	7	1	1	1	3	2	1	3	1	1	1	1	1	2	2	2	1	2	0	3	1	0	1	2
		1	C	SW	S	I	1	35	Kareem Ashraf	M	7	1	1	1	2	2	1	3	1	1	1	1	1	2	2	2	2	1	2	1	1	0	1	1
		1	C	SW	S	I	1	36	Mohamed Gamal	M	7	1	1	1	2	2	1	3	1	1	1	1	1	2	2	1	2	1	2	3	1	0	1	1
		1	C	SW	S	I	1	37	Mahmoud Salam	M	7	1	1	1	2	2	2	3	1	1	1	1	2	0	2	2	2	1	2	3	2	2	1	1
		1	C	SW	S	I	1	38	Ahmed Atef	M	7	1	1	1	2	2	1	3	1	1	1	1	2	0	2	2	2	1	2	2	2	1	1	1
		1	C	SW	S	I	1	39	Kareem Mokhtar	M	7	1	1	1	2	2	1	3	1	1	1	1	2	0	2	2	2	1	2	1	2	1	1	1
		1	C	SW	S	I	1	40	Abd Alrahman Ahmed	M	7	1	1	1	1	2	2	3	1	1	2	1	2	0	2	2	2	1	2	1	2	1	1	1

Al-Minya	Omar ebn al-Khatab	1	C	SW	S	I	1	41	Mohamed Ezat	M	7	1	1	1	2	2	2	3	1	1	1	1	2	0	2	2	2	1	2	3	1	0	1	2
		1	C	SW	S	I	1	42	Aiman Mohamed	M	7	1	1	1	1	1	1	3	1	1	1	3	1	1	2	1	2	1	2	2	1	0	2	1
		1	C	SW	S	I	1	43	Hassan Mostafa	M	7	1	1	1	1	2	1	3	1	1	1	1	1	2	2	1	2	1	2	1	1	1	1	1
		1	C	SW	S	I	1	44	Mohamed Abd Elwahab	M	7	1	1	1	2	2	1	3	1	1	1	1	2	0	2	2	2	1	2	3	2	1	1	1
		1	C	SW	S	I	1	45	Mohamed Mohei	M	7	1	1	1	2	2	1	3	1	1	2	3	1	2	2	1	2	1	2	4	2	1	2	1
		1	C	SW	S	I	1	46	Ahmed Farouq	M	7	1	1	1	3	1	1	3	1	1	1	3	1	2	2	1	2	1	2	3	2	1	2	1
		1	C	SW	S	I	1	47	Abd Allah Alaa	M	7	2	2	2	3	2	1	3	1	1	2	2	1	1	2	2	2	1	2	4	2	1	2	1
		1	C	SW	S	I	1	48	Ahmed Hussein	M	7	1	1	1	3	1	1	3	1	1	1	3	2	0	2	1	2	1	2	2	2	1	2	1
		1	C	SW	S	I	1	49	Roqia Mohamed	F	7	3	1	1	2	1	2	3	1	3	2	1	1	2	2	2	1	1	2	2	2	1	1	2
		1	C	SW	S	I	1	50	Basma Gamal	F	7	3	3	2	2	2	2	3	1	3	2	1	1	3	2	1	2	1	2	3	1	0	1	2
		1	C	SW	S	I	1	51	Mona Saleh	F	7	3	0	1	2	2	2	3	1	3	1	1	1	3	2	1	2	1	2,3	1	1	0	1	2
		1	C	SW	S	I	1	52	Omar Hussien	M	7	1	1	1	1	1	1	3	1	1	1	3	1	1	2	1	2	1	2	2	1	0	2	1
		1	C	SW	S	I	1	53	Heba Said	F	7	3	3	1	3	1	1	3	1	1	1	3	1	1	2	1	2	1	2	1	1	0	2	1
		1	C	SW	S	I	1	54	Hoda Mokhtar	F	7	3	3	1	2	2	2	3	2	3	2	1	1	2,3	2	2	2	1	2,3	2	1	1	1	2
		1	C	SW	S	I	1	55	Hadeer Mahmoud	F	7	1	3	1	2	1	1	3	1	1	1	1	1	2,3	2	2	2	1	2,3	2	2	1	1	2
		1	C	SW	S	I	1	56	Nagat Ahmed	F	7	3	3	1	2	2	1	3	1	1	1	3	1	1	2	1	2	1	2	1	1	0	2	1
		1	C	SW	S	I	1	57	Hajar Salh	F	7	3	3	1	2	2	2	3	2	3	2	1	1	2,3	2	1	2	1	2,3	1	1	0	1	2
		1	C	SW	S	I	1	58	Hajar Adel	F	7	3	3	2	2	2	1	3	1	1	1	1	1	2,3	2	1	2	1	2,3	2	2	1	1	2
		1	C	SW	S	I	1	59	Amena Mohamed	F	7	3	1	1	3	2	1	3	1	1	1	3	1	1	2	1	2	1	2	1	1	0	2	1
		1	C	SW	S	I	1	60	Shaimaa Alaa	F	7	3	2	1	3	2	1	3	1	1	1	3	1	1	2	1	2	1	2	1	1	0	2	1
		1	C	SW	S	I	1	61	Rehab Said	F	7	3	3	1	2	2	2	3	2	1	2	1	1	2,3	2	1	2	1	2,3	1	1	0	1	2
		1	C	SW	S	I	1	62	Nada Alaa	F	7	3	1	1	3	1	1	3	1	1	1	3	1	1	2	1	2	1	2	1	1	0	2	1
		3	C	NW	S	Q	6	67	Mohamed Kamel	M	12	2	1	2	3	3	2	3	1	1	1	1	1	3	2	0	0	2	0	2	1	0	1	1
		3	C	NW	S	Q	6	68	Reham Mohamed	F	12	3	3	1	3	1	2	3	1	1	1	1	1	1	2	2	2	1	2	1	1	0	1	1
		3	C	NW	S	Q	6	69	Zainab Ibraheem	F	12	3	3	1	3	1	2	3	1	1	1	1	1	1	2	2	2	1	2	1	1	0	1	1
		3	C	NW	S	Q	6	70	Raafat Mosa	M	12	1	1	1	2	2	2	3	1	3	2	2	1	2	2	1	2	1	2	3	1	0	2	1
		3	C	NW	S	Q	6	71	Hadeer Hamada	F	12	3	3	2	2	2	1	3	1	1	1	1	1	2	2	1	2	1	2	1	1	0	1	1
		3	C	NW	S	Q	6	72	Enji Osama	F	12	3	3	1	2	1	1	3	1	1	2	1	1	2	2	1	2	1	2	1	1	0	2	1
		3	C	NW	S	Q	6	73	Marina Malak	F	12	3	3	2	2	2	1	3	1	1	1	1	1	2	2	1	2	1	2	1	1	0	1	1
		3	C	NW	S	Q	6	74	Yousef Amin	M	12	1	3	1	1	3	2	3	1	1	2	1	1	2	2	2	2	1	3	1	2	1	1	1
		3	C	NW	S	Q	6	75	Mohamed Mady	M	12	1	1	1	2	2	1	3	1	3	1	3	1	1	1	2	0	1	2	3	2	1	1	1
		3	C	NW	S	Q	6	76	Mostafa Khaled	M	12	1	1	1	1	2	1	3	1	1	2	1	1	2	2	1	1	1	2	1	1	0	1	1
		3	C	NW	S	Q	6	77	Aiaa Esmaiel	F	12	3	3	1	2	3	1	3	1	1	1	3	1	1	2	1	1	1	1	4	1	0	1	1
		3	C	NW	S	Q	6	78	Kareem Makhloof	M	12	2	1	1	3	1	2	2	2	1	1	1	1	3	2	1	2	1	2	1	1	0	3	1
		3	C	NW	S	Q	6	79	AlHasan Hussien	M	12	2	1	1	1	1	2	3	2	1	1	1	1	3	2	1	2	1	2	1	1	0	3	1
		3	C	NW	S	Q	6	80	Abanob Meshiel	M	12	2	3	1	2	2	1	3	1	1	2	1	1	3	2	1	2	1	2	1	1	0	3	1

Al-Minya

Al-lamaty

3	C	NW	S	Q	6	81	Gehad Raffat	F	12	3	3	1	1	3	2	3	2	3	2	2	1	2	2	1	1	1	2	3	1	0	2	1
3	C	NW	S	Q	6	82	Mostafa Mamdouh	M	12	2	2	1	2	2	1	3	1	1	2	1	1	2	2	1	2	1	2	4	1	0	1	1
3	C	NW	S	Q	6	83	Sami Khaled	M	12	3	1	1	1	3	1	3	2	3	2	1	1	2	2	1	2	1	2	3	1	0	2	1
3	C	NW	S	Q	6	84	Beshou Magdi	M	12	2	1	2	1	1	1	3	1	1	2	1	1	2	2	1	2	1	2	2	1	0	2	1
3	C	NW	S	Q	6	85	Esraa Gamal	F	12	3	1	2	1	3	2	3	2	1	2	1	1	2	2	1	2	1	2	3	1	0	1	1
3	C	NW	S	Q	6	86	Maha Saad	F	12	3	1	1	2	3	1	3	1	3	2	1	1	1	2	1	2	1	2	3	1	2	1	1
3	C	NW	S	Q	6	87	Hanaa Mahmoud	F	12	3	3	1	2	3	1	3	1	3	2	1	1	1	2	1	1	1	2	3	1	0	3	1
3	C	NW	S	Q	6	88	Abd Elrahman Ahmed	M	12	1	1	2	2	1	2	3	1	1	2	1	1	1	1	1	2	1	2	3	1	0	2	1
3	C	NW	S	Q	6	89	Kareem Hamdi	M	12	1	1	2	2	1	2	3	1	1	2	1	1	1	2	1	2	1	2	3	1	0	2	1
3	C	NW	S	Q	6	90	Ahmed Medhat	M	12	1	1	2	2	1	2	3	1	1	2	1	1	1	2	1	2	1	2	3	1	0	2	1
3	C	NW	S	Q	6	91	Kamel Esmaiel	M	12	1	1	1	1	3	2	3	1	1	2	1	2	0	2	1	1	1	2	3	1	0	2	1
3	C	NW	S	I	6	92	Mohamed Hassan	M	12	1	1	1	3	3	1	2	1	1	2	2	1	1	2	1	2	1	2	3	1	0	2	1
3	C	NW	S	I	6	93	Yousef Shehata	M	12	1	1	1	2	2	2	3	1	1	2	1	1	3	2	1	2	1	2	2	1	0	1	1
3	C	NW	S	I	6	94	Mahmoud Alaa	M	12	2	1	2	1	1	1	3	1	1	2	1	1	1	2	1	2	1	2	2	1	0	2	1
3	C	NW	S	I	6	95	Amjad Maher	M	12	2	2	2	3	1	2	1	3	1	1	1	1	2	2	2	2	1	2	3	1	0	2	1
3	C	NW	S	I	6	96	Fatema Mohamed	F	12	3	3	1	2	1	1	3	1	1	2	1	1	2	2	1	2	1	2	1	1	0	2	1
3	C	NW	S	I	6	97	0	F	12	1	1	1	1	3	1	3	2	1	2	1	1	2	2	1	2	1	3	1	1	0	1	1
3	C	NW	S	I	6	98	0	F	12	1	1	1	3	3	2	3	1	1	2	1	1	3	2	1	2	1	1	1	1	0	1	1
3	C	NW	S	I	6	99	Sali Mamdouh	F	12	3	3	1	3	1	2	3	1	1	1	1	1	2	2	2	2	1	2	1	1	0	1	1
3	E	SE	S	Q	5	100	Mena Jousef	M	11	2	2	1	2	2	1	3	2	3	2	1	2	0	2	1	2	1	2	3	1	0	1	1
3	E	SE	S	Q	5	101	Omar Esmaiel	M	11	2	1	1	1	1	1	3	2	2	1	1	1	2	2	2	2	1	2	1	2	1	3	2
3	E	SE	S	Q	5	102	Fathi Mohamed	M	12	0	1	2	1	1	1	3	1	1	2	1	1	3	1	1	1	1	1	4	1	0	1	1
3	E	SE	S	Q	5	103	Nourhan Gamal	F	11	2	2	2	2	2	2	3	1	1	2	1	1	2	1	1	2	1	2	4	1	0	1	1
3	E	SE	S	Q	5	104	Abanoub Helmy	M	12	2	2	2	2	2	1	3	1	1	2	1	1	2	1	1	2	1	2	3	2	1	1	1
3	E	SE	S	Q	5	105	Marout Tobia	M	11	1	1	2	2	1	2	3	1	1	2	2	1	3	2	2	2	1	2	3	1	0	1	1
3	E	SE	S	Q	5	106	Jousef Malak	M	11	1	1	2	2	1	1	3	1	1	1	1	1	1	2	1	2	1	1	4	1	0	1	1
3	E	SE	S	Q	5	107	Salsabil Ashraf	M	11	3	1	2	2	3	2	3	1	1	2	1	1	2	1	2	2	1	2	1	2	1	1	1
3	E	SE	S	Q	5	108	Aia Ramadan	F	11	3	3	2	3	1	2	2	1	3	1	1	2	0	2	1	2	1	2	0	1	0	3	1
3	E	SE	S	Q	5	109	Ahmed Mahmoud	M	11	2	2	2	3	1	1	2	1	1	2	3	1	3	1	1	2	1	3	3	1	0	1	1
3	E	SE	S	Q	5	110	Mostafa Dosoki	M	11	2	2	2	1	1	1	3	1	1	1	1	1	2	2	2	2	1	2	1	2	1	1	2
3	E	SE	S	Q	5	111	Marina Adel	F	10	3	3	1	3	2	1	3	1	3	1	1	1	2	2	2	2	1	2	3	1	0	1	1
3	E	SE	S	Q	5	112	Mariet Boutros	F	10	3	3	1	3	2	1	3	1	3	1	1	1	2	2	2	2	1	2	3	2	1	1	1
3	E	SE	S	Q	5	113	Ahmed Hani	M	11	2	2	1	2	1	1	3	1	1	2	1	1	0	2	1	1	1	1	2	1	0	2	1
3	E	SE	S	Q	5	114	Nashwa Mohamed	F	11	3	3	2	3	1	2	3	2	3	1	1	2	0	2	2	2	1	2	1	1	0	3	1
3	E	SE	S	I	5	115	Nermin Alaa	F	12	3	3	1	3	3	1	3	1	3	1	1	1	1	1	2	2	1	1	1	2	1	1	2
3	E	SE	S	I	5	116	Ahmed Osam	M	12	3	2	1	3	1	1	3	1	3	1	1	1	2	2	2	2	1	2	1	2	1	1	2
3	E	SE	S	I	5	117	Ahmed Saleh	M	12	1	2	1	3	1	1	3	1	3	1	1	1	2	2	2	2	1	2	1	2	1	1	2

Al-Minya

Al-Shaheed

3	E	SE	S	I	5	118	Kareem Sharkawi	M	11	1	1	1	1	1	1	3	1	1	0	1	1	0	2	1	2	1	1	3	1	0	1	1
3		SE	S	I	5	119	Ahmed Mohameed	M	11	1	1	1	3	1	1	2	1	1	1	1	1	0	2	1	2	1	1	2	2	1	1	1
1	C	N	S	Q	7	131	Khiri Rabeea	M	12	3	3	1	3	0	1	3	1	3	1	1	1	0	2	2	2	1	3	2	2	1	3	1
1	C	N	S	Q	7	132	Abd Elrahaman Fathi	M	9	2	3	1	1	1	1	3	2	1	2	1	2	0	2	1	1	1	3	4	1	0	1	1
1	C	N	S	Q	7	133	Aiman Alaa Abdou	M	10	2	3	1	1	1	1	3	2	1	1	1	2	0	2	1	1	1	3	4	1	0	1	1
1	C	N	S	Q	7	134	Marwa Reda	F	9	3	3	1	1	3	2	3	2	1	2	1	1	3	2	2	2	1	2	1	2	1	1	1
1	C	N	S	Q	7	135	Aia Kamal	F	9	3	3	1	3	1,3	2	3	2	1	2	1	1	3	2	2	2	1	2	1	2	2	1	1
1	C	N	S	Q	7	136	Ahmed Saad	M	9	1	1	1	1,3	1	2	3	1	1	2	1	1	0	1	0	0	0	0	1	0	0	0	2
1	C	N	S	Q	7	137	Mona Naser Taha	F	9	3	3	1		3	2	3	2	1	2	1	2	0	1	1	1	1	2	3	2	1	1	1
1	C	N	S	Q	7	138	Asmaa Adel	F	9	3	3	1	1	3	2	3	2	1	2	1	2	0	2	1	1	1	2	4	1	0	1	1
1	C	N	S	Q	7	139	Nada Aly	F	8	3	3	1	1	3	2	3	2	1	2	1	2	0	1	1	1	1	2	3	2	1	1	1
1	C	N	S	Q	7	140	Menat Allah Mohamed	F	9	3	3	2	2	3	1	3	1	1	2	3	2	0	2	2	1	1	1	1	1	0	2	1
1	C	N	S	Q	7	141	Mona Saber	F	8	3	3	1	2,3	3	1	3	1	1	2	1	1	3	2	2	2	1	1	1	2	1	2	2
1	C	N	S	Q	7	142	Hend Hussein	F	9	1,3	3	1	3	1,3	1	3	1	1	2	1	1	3	2	2	2	1	1	1	2	1	2	2
1	C	N	S	Q	7	143	Hajer Ahmed	F	9	1	3	1	3	3	2	3	2	1	2	2	1	3	2	1	2	1	2	1	1	0	3	1
1	C	N	S	Q	7	144	Omar Hassan	M	12	3	3	1,2	3		2	1	1	1	1,2	1,2	1	0	0	2			2	1	1	0	1	1
1	C	N	S	Q	7	145	Aia Saaid	F	9	1	3	1	3	1,3	1	3	1	1	2	1	1	2	2	2	1	1	1	1	2	1	2	2
1	C	N	S	Q	7	146	Amina Mahmoud	F	9	1	3	1	3	3	2	3	2	1	2	2	1	3	2	1	2	1	2	1	1	0	3	1
1	C	N	S	Q	7	147	Abd Elrahman Mahmoud	M	12	3	3	1	3	3	0	3	1	1	1	3	1	0	1	1	2	1	1	4	1	0	1	1
1	C	N	S	Q	7	148	Sondos Yauhia	F	9	3	1	1	1	2	2	3	1	1	1	2	1	2	1	1	2	1	2	1	1	0	1	1
1	C	N	S	Q	7	149	Amena Ragab	F	9	3	3	1	3	3	2	3	2	1	2	2	1	3	2		1	1	1	1	2	1	2	2
1	C	N	S	Q	7	150	Samar Gamal	F	9	3	1	1	1	2	2	3	1	1	1	2	1	3	1	1,2	1	1	1	1	2	1	2	2
1	C	N	S	Q	7	151	Shaimaa Habeeb	F	9	1,2																						
1	C	N	S	Q	7	152	Eman Gamal	F	9	2,3	2	1,2	1	1	1	1	1	1	1	1	1	0	2	1	2	1	1	1	1	1	1	1
1	C	N	S	Q	7	153	Ahmed Magdi	M	9	1	1	2	2	2	2	2	2	1	2	2	1	0	1		2		2	1	1	0	1	1
1	C	N	S	Q	7	154	Alaa	M	12	2	3	1	2	2	2	2	0	2	2	1	1	3	1	1	2	1	2	3	2	2		2
1	C	N	S	Q	7	155	Abd Elrahman Hassan	M	12	2	2	1	2	3	2	2	1	2	2	1	1	3	1		2		1	3	1	0	1	2
1	C	N	S	Q	7	156	Aly Shaaban	M	12	3	3	1	1	1	0	0	1	0	0	1	1	0	1	2	2	1	3	3	1	2	1	1
1	C	N	S	Q	7	157	Nourhan Hassan	F	9	3	3	1	1	1	1	3	1	1	1	3	2	0	1	2	1	1	3	4	1	0	1	2
1	C	N	S	Q	7	158	Hend Kamal	F	9	3	3	1	3	1	2	1	2	1	1	1	1	0	2	1	1	1	1	1	1	0	1	1
1	C	N	S	Q	7	159	Walaa Abd Elaziz	F	8	3	3	1	2	1	2	3	1	1	1	3	2	0	1	1	1	1	1	2	1	0	1	1
1	C	N	S	Q	7	160	Nermin Reda	F	9	3	3	1	1	3	2	3	2	1	1	2	1	2	1	1	2	1	2	1	1	0	1	1
1	C	N	S	I	7	161	Hend Osman	F	10	1	3	1	2	2	1	3	1	3	1	2	1	2	2	2	1	1	2	3	2	1	1	1
1	C	N	S	I	7	162	Mostafa Fadl	M	10	3	3	1	3	3	1	3	1	3	2	2	0	1	1	1	1	2	0	5	1	0	1	1
1	C	N	S	I	7	163	Shaaban Hassan	M	9	3	3	1	2	3	1	3	1	3	2	0	2	0	1	1	2	1	3	7	2	2	1	1
1	C	N	S	I	7	164	Gehad Fathi	F	9	2	2	1	1	1	2	3	1	3	2	1	2	0	2	1	1	1	1	4	1	0	1	1
1	C	N	S	I	7	165	Ahmed Taha	M	10	3	3	1	1	1	1	3	2	1	2	1	2	0	2	1	1	1	3	4	1	0	1	1

1	C	N	S	I	7	166	Islam Adel	M		2		1	3	1	2	1	1	3	2	1	2	0	2		1	1	1	4	1	0	3	2
1	C	N	S	I	7	167	Rahma Alaa	F	10	2	2	1	1	1	2	3	1	3	2	1	2	0	2	1	1	1	3	4	1	0	1	1
1	C	N	S	I	7	168	Nourhan Ahmed	F	9	1,3	1,3	2	1,3	1	2	2	1	1	2	1	1	3	2	2	2	1	2	1	2	1	1	1
1	C	N	S	I	7	169	Mohamed Habashi	M	9	1	1	1	1	3	1	2	3	1	2	2	1	0	1	2	2	1	2	3	1	0	3	1
G	C	W	S	Q	8	170		M	10	1	2	1	1	1	1	3	1	3	1	1	1	2	2	2	2	1	2	1	2	1	1	1
G	C	W	S	Q	8	171	Ahmed Khalil	M	12	2	2	1	1	1	1	3	2	3	2	1	2	0	2	2	2	1	2	2	1	0	1	1
G	C	W	S	Q	8	172	Mohamed Ali	M	11	1	2	1	1	1	1	3	1	3	2	1	1	3	2	2	2	1	2,3	1	1	0	1	1
G	C	W	S	Q	8	173	Hamdi Ali	M	10	3	2	1	1	1	1	3	1	1	1	1	1	1	2	2	2	1	2	2	2	1	1	1
G	C	W	S	Q	8	174	Salah Ibraheem	M	12	2	3	1	2	1	2	3	2	3	2	3	1	3	2	2	2	1	2	3	1	0	1	1
G	C	W	S	Q	8	175	Naser Hussien	M	12	1	2	1	2	1	1	3	1	1	1	1	1	2,3	2	2	2	1	1,2,3	1	2	1	1	1
G	C	W	S	Q	8	176	Eihab Botrus	M	11	2	2	1	1	2	1	3	1	3	2	3	1	2	2	2	2	1	1,2,3	3	1	0	1	1
G	C	W	S	Q	8	177	Salwa Atia	F	11	1	3	1	2	2	1	3	1	1	1	1	1	3	2	2	1	1	2	2	2	1	1	1
G	C	W	S	Q	8	178	Ishaq Yousef	M	11	2	3	1	2	2	2	3	1	3	2	2	1	2	2	1	2	1	2	3	1	0	1	1
G	C	W	S	Q	8	179	Ahmed Ebraheem	M	11	3	3	1	2	2	2	3	2	1	2	3	1	2	2	1	2	1	2	4	1	0	1	1
G	C	W	S	Q	8	180	Salah Hamdi	M	10	3	2	1	2	2	1	3	1	3	1	1	1	3	2	2	2	1	2	2	1	0	1	1
G	C	W	S	Q	8	181	Ahmed Mohamed	M	11	3	2	1	2	2	1	3	1	1	1	1	2	0	2	2	2	1	2,3	2	2	1	1	1
G	C	W	S	Q	8	182	Mohamed Kamal	M	11	2	3	1	2	2	1	3	1	1	2	1	1	3	2	2	2	1	2	3	1	0	1	1
G	C	W	S	Q	8	183	Laila Aly	F	12	1	2	1	2	2	1	3	1	3	1	2	1	2,3	2	2	0	1	2,3	1	2	1	1	1
G	C	W	S	Q	8	184	Reda Mohamed	M	11	1	3	1	2	2	1	3	1	3	1	3	2	0	2	2	2	1	2	2	1	0	1	1
G	C	W	S	Q	8	185	Ahmed Reda	M	11	2	3	1	2	2	1	3	1	3	2	2	1	2	2	1	2	1	2,3	4	1	0	1	1
G	C	W	S	Q	8	186	Hanna Abd Elrahman	F	10	3	3	1	2	2	2	3	1	3	2	1	1	2,3	2	2	1	1	2	4	2	1	1	1
G	C	W	S	Q	8	187	Hend Mohamed	F	11	1	2	1	2	2	1	3	1	3	1	1	1	2,3	2	1	2	1	2	2	1	0	1	1
G	C	W	S	Q	8	188	Abd Elrahman Ahmed	M	10	2	3	1	2	2	2	3	1	1	2	2	1	3	2	1	2	1	2,3	3	2	1	1	1
G	C	W	S	Q	8	189	Abd Allah Mohamed	M	11	3	0	1	2	2	2	3	1	1	2	2	1	2	2	1	2	1	2,3	4	1	0	1	1
G	C	W	S	I	8	190	Hassan Mahmoud	M	10	2	2	1	2	2	2	3	1	1	2	1	1	2,3	2	1	2	1	2,3	3	1	0	1	1
G	C	W	S	I	8	191	Ahmed Hassan	M	11	1	2	1	2	2	1	3	1	1	1	1	1	3	2	2	2	1	2,3	2	2	1	1	1
G	C	W	S	I	8	192	Salwa Ahmed	F	11	1	2	1	2	2	1	3	1	1	1	2	1	2	2	2	1	1	2,3	2	1	0	1	1

Questions			Location
1			School's name
			Teachers T / Students S
			Questionnaire Q / Interview I
			ID
			Name
			Gender M /F
			Age
2	Teachers' questionnair and interview questions		Are the windows still opened all of the time? (Yes 1 / most of the time 2 / some time 3)
3			Does the sun penetrate the classroom through the windows? (Yes 1/ sometime 2 / No 3)
4			does the sun penetration bother you? (Yes 1/ No 2)
5			Are the windows still closed all of the time? (Yes 1 / most of the time 2 / some time 3)
6			Do you prefer if there are curtains on the windows? (Yes 1/ No 2)
7			What kind of clothes you wear these days? (Light 1 / Heavy 2 / Medium 3)
8			Does the sun come over your seat during the day? (Yes 1 / No 2)
9			Do you feel that you want to take off some of your clothes? (Yes 1 / No 2 / to roll up my sleeves 3)
10			Do you prefer if some classes to take outside the classroom? (Yes 1 / No 2)
11			When you prefer to take the classes outside? (Morning 1 / During the noon time 2 / After noon 3)
12			Does the classroom in general comfortable? (Yes 1 / No 2)
13			Do you prefer to wear a complete sleeves or half sleeves these days? (Complete 1 / Half 2)
14			Do you prefer if your classroom provided with fans? (Yes 1 / No 2)
15			When you want these fans to work? (Morning 1 / During the noon time 2 / After noon 3))
16			How do you feel ? (hot 3 / warm2 / Slightly Warm 1 / Neutral 0 / Slightly cool -1 / cool -2 / cold -3)
17			Does the classroom area suitable? (Yes 1 / No 2)
18			Do you prefer it different? (Bigger 1 / Smaller 2)
19			Do you feel some times that the classroom not comfortable? (Yes 1 / No 2)
20			Do you feel that the performance of the students is affected by the temperature degree inside the classroom? (Yes 1 /No 2)
21			Do you open the windows on the corridor? (Yes 1 / No 2 / no windows on the corridor)
22			Do you close the classroom's door during the day? (yes 1, No 2)
23			Which bother the students more; the hot summer or the cold winter? (the hot summer 1 /The cold winter 2 / Both 3 / non of them 4)
24			What are the students do when they bothered from the sun penetration? (Move around 1 / stick some papers on the windows 2 / Nothing 3 / Take off some of their clothes 4)
25		Do you prefer to	For the direction (North 1 / East 2 / South 3 / West 4)
			For the floor levels (Ground 1 / Middle 2 / Top 3)
			For the classroom osition (Middle 1 / Edge 2)

Belbis	Sekem	T	Q	25	Mohamed Anour	M	25	3	1	2	0	2	3	2	3	1	2	1	1	2	0	4	1	0	2	1	3	1	1	1	0	3	0
Belbis	Sekem	T	Q	26	Mohamed Hasona	M	32	2	3	2	3	2	3	2	2	1	3	1	1	2	0	4	1	0	2	1	3	1	1	1	4	1	1
Belbis	Sekem	T	Q	27	Hosam Hafez	M	36	1	2	2	0	1	3	2	3	2	0	0	1	1	1	2	2	1	0	2	3	1	4	2	1,2,3,4	1,2,3	1,2
Belbis	Sekem	T	I	28	Ursla Feltas	F	40	2	1	2	3	2	1	2	2	1	2,3	1	2	2	0	3	1	0	1	1	3	1	1	1	1	1	1
Belbis	Sekem	T	I	29	Gamal	M	50	2	2	2	3	2	3	2	2	1	2,3	1	2	2	0	4	1	0	2	1	3	1	1	1	1,2	1	1,2
Belbis	Sekem	T	I	30	Salem ElMasry	M	40	2	2	2	3	2	3	2	3	2	0	1	1	1	2	4	1	0	2	1	3	1	3	2	1	2	1
Al-Minya	Omar ebn al-	T	Q	64	Mona Ragab	F	38	1	1	1	3	2	1	1	1	1	2	2	2	1	2	1	2	1	1	1	1	1	3	2	4	1	1
Al-Minya	Omar ebn al-	T	Q	65	0	F	0	1	1	1	3	2	3	1	1	1	2,3	2	2	1	2,3	2	2	1	1	1	1	1	3	1,2	2	2	1
Al-Minya	Omar ebn al-	T	Q	66	0	F	0	2	1	3	3	1	1	1	1	1	2,3	2	2	1	2,3	1	2	1	1	1	1	1	3	2,4	1	2	1
Al-Minya	Al-lamaty	T	Q	120	Om Gerges	F	54	1	1	2	3	0	3	2	2	2	0	1	1	2	0	4	1	0	2	1	1	1	1	1,2	1,2	0	0
Al-Minya	Al-lamaty	T	Q	121	Hanan Kamel	F	35	2	2	1	3	1	3	1	1	2	0	1	2	1	2	3	1	0	1	1	1	1	3	2	1	1	
Al-Minya	Al-lamaty	T	Q	122	Sabah Saied	F	43	1,2	2	1	3	1	3	1	1	2	0	1	2	1	2	3	1	0	1	1	1	1	3	2	1	0	0
Al-Minya	Al-lamaty	T	Q	123	Laila Mortada	F	48	2	2	1	3	1	3	1	1	2	0	1	1	1	2	4	2	1	1	1	1	1	1	1	1	2	2
Al-Minya	Al-lamaty	T	Q	124	Hana Badran	F	48	3	2	1	1	1	3	0	1	1	1	1	1	1	2	3	1	0	1	1	1	1	3	2	2	2	1
Al-Minya	Al-lamaty	T	Q	125	Amal	F	45	1	2	2	3	1	3	2	3	1	2	1	1	1	2	3	1	0	1	1	1	1	1	2	0	0	0
Al-Minya	Al-lamaty	T	Q	126	Sami Georg	M	41	2	1	2	3	2	1	2	3	1	1	1	2	1	3	3	1	0	2	1	2	1	1	2	1	2	2
Al-Minya	Al-lamaty	T	Q	127	Basem Salah	M		1	1	1	3	1	3	1	3	1	2	1	2	1	2	3	1	0	1	1	2	1	3	1	1	1	1
Al-Minya	Al-lamaty	T	I	128	Shehata Fahmi	M	45	2	2	1	3	1	3	1	3	1	3	2	2	1	2,3	3	2	1	1	1	1	1	3	1,2	1	2	1
Al-Minya	Al-lamaty	T	I	129	Mohamed Farouq	M	35	1	2	1	3	1	3	1	3	1	2	2	2	1	2,3	3	2	1	1	1	1	1	3	1,2,3	2	2	1
Al-Minya	Al-lamaty	T	I	130	Magdi Ezat	M	34	2	2	2	3	1	1	2	3	2	0	1	2	1	2,3	3	1	0	1	1	1	2	3	2,4	1	2	2
Al-Minya	Al-Shaheed	T	Q	193	Salama	M	45	2	2	1	3	1	1	1	1	1	2,3	2	2	1	2,3	3	2	1	1	1	1	1	3	1,2,4	1,2	2	1
Al-Minya	Al-Shaheed	T	Q	194	School headteacher	F	50	2	2	2	3	1	3	2	2	1	3	2	1	1	2,3	3	2	1	1	1	1	1	3	1,2,4	1,2	1,2	1
Al-Minya	Al-Shaheed	T	Q	195	Heba Mohamed	F	31	1	2	2	3	2	1	2	2	2	0	1	1	1	2	2	2	1	1	1	1	1	1	1,4	0	0	0
Al-Minya	Al-Shaheed	T	Q	196	Afaf Louse	F	27	2	2	2	3	1	3	2	2	2	0	1	1	1	2	3	1	0	2	1	1	1	1	1	0	0	0
Al-Minya	Al-Shaheed	T	Q	197	Amani Fouad	F	30	1	1	2	3	1	3	2	2	2	0	1	1	1	2	3	1	0	1	1	1	1	1	1	0	0	0
Al-Minya	Al-Shaheed	T	Q	198	Mona Gamal	F	32	2	2	2	0	1	3	2	2	2	0	1	1	1	2	3	1	0	2	1	1	1	1	2	0	0	0
Al-Minya	Al-Shaheed	T	I	199	Amal	F	35	2	0	2	3	1,2	3	2	2	1	1	1	1	1	2	3	1	0	1	1	1	1	3	2	4	2	1
Al-Minya	Al-Shaheed	T	I	200	Aml Abd Elqader	F	35	1	2	2	3	2	3	2	2	1	1	1	1	1	2	4	2	1	1	1	1	1	3	2	4	2	1

Appendix 9:
MRT calculations

Appendix 9: MRT calculations for a seated person inside the classrooms of the governmental primary schools

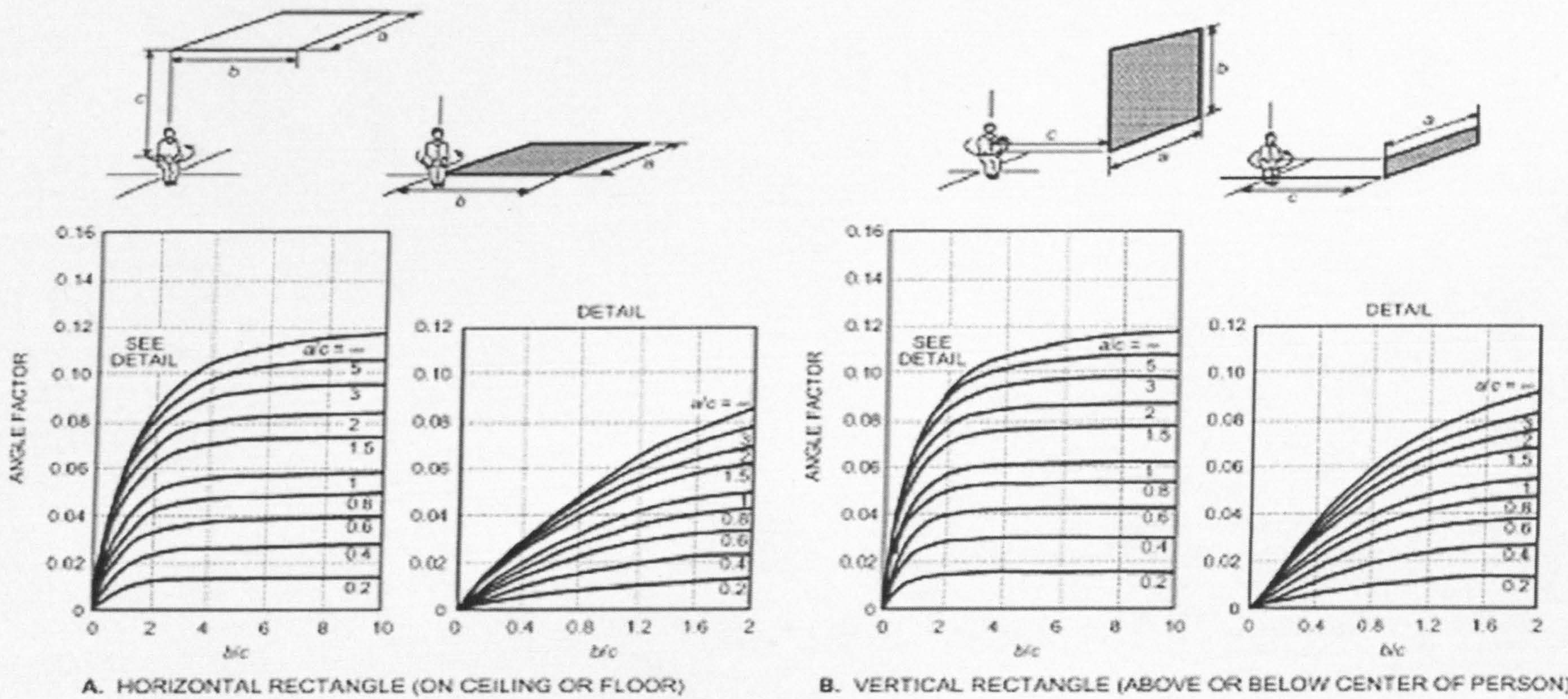

Figure 1: Calculating the angel factor graphically for horizontal and vertical surfaces, after Fanger 1982, quoted in ASHRAE [1]

By calculating a/b and a/c the angle factor could be identified on the graph

Where:

a and b: are the length and width of the horizontal/vertical surface

c: is the distance between the person and the surface

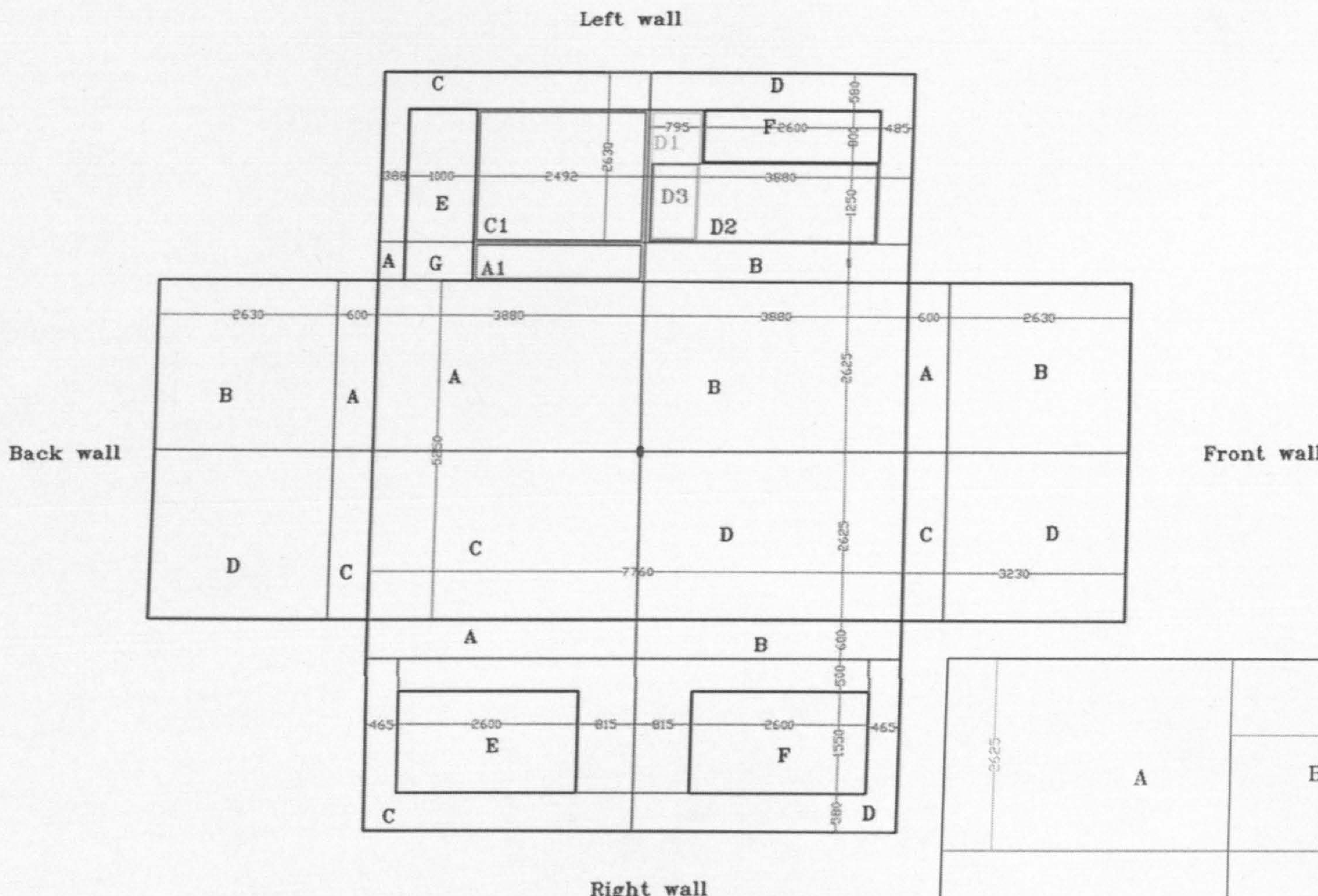

Figure 2: Surfaces areas for the floor and the walls

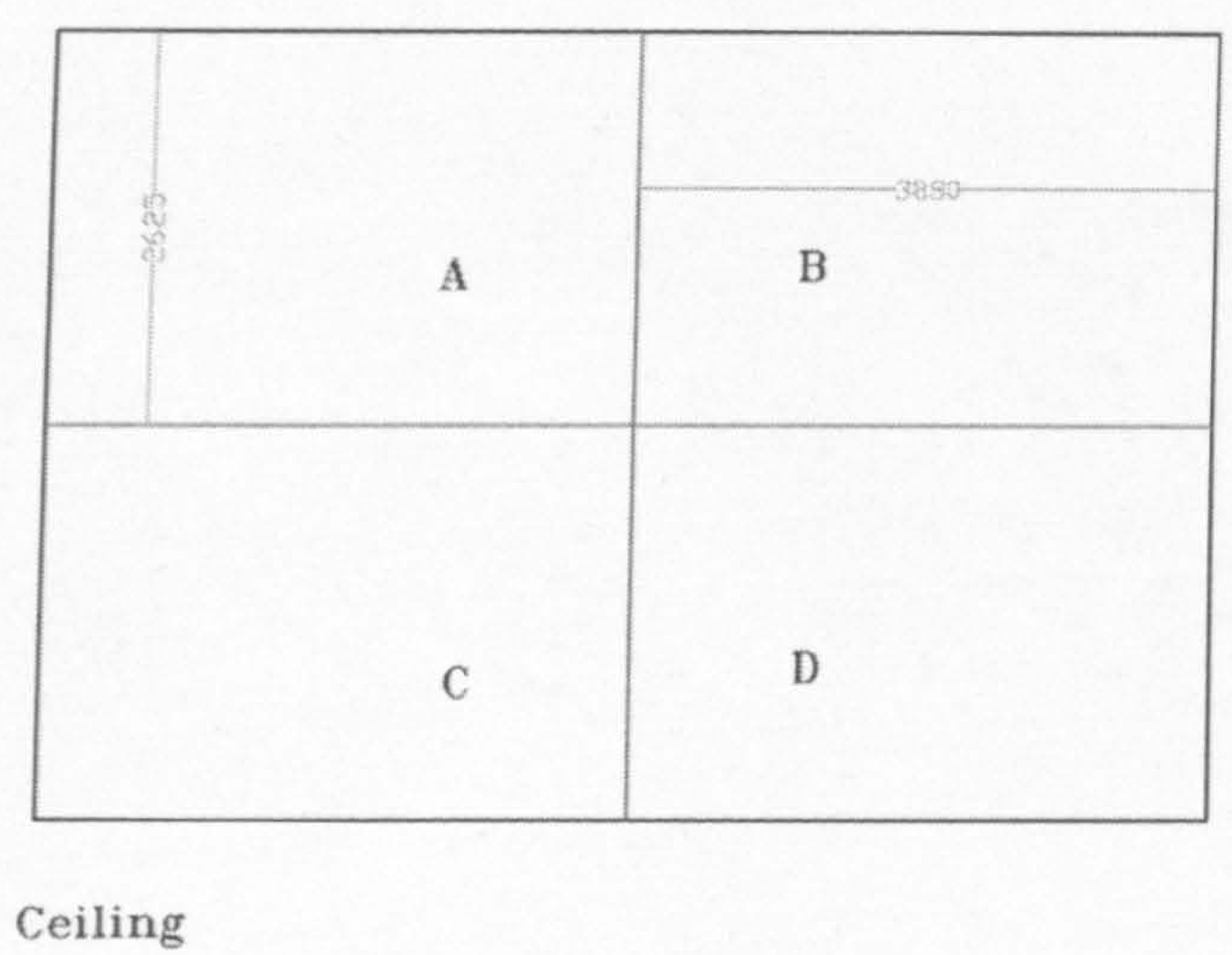

Figure 3: Surface areas of the ceiling

Table 1: MRT calculation for a seated person

Surface		Space dimensions	7760	5250	3230					Omar ebn al-KhatabCase study-1		El-Lamaty				Al-Shaheed			
												Case study-2		Case study-3		Case study-4		Case study-5	
		Fp.n	a	b	c	a/c	b/c		Angle Factor (from the figure)	Tr	Tr *Angle factor	Tr	Tr *Angle factor	Tr	Tr *Angle factor	Tr	Tr *Angle factor	Tr	Tr *Angle factor
Front wall	A	Fp.a	2625	600	3880	0.68	0.15		**0.010**	24.7	0.247	23.9	0.239	22.2	0.222	23.1	0.231	25.5	0.255
	B	Fp.b	2625	2630	3880	0.68	0.68		**0.030**	24.7	0.741	24.6	0.738	22	0.66	23.4	0.702	25.7	0.771
	C	Fp.c	2625	600	3880	0.68	0.15		**0.010**	24.8	0.248	23.9	0.239	22.2	0.222	23.1	0.231	25.5	0.255
	D	Fp.d	2625	2630	3880	0.68	0.68		**0.030**	24.8	0.744	24.6	0.738	22	0.66	23.4	0.702	25.7	0.771
Right wall	A	Fp.a	3880	600	2625	1.48	0.23		**0.020**	22.1	0.442	25.7	0.514	22	0.44	25.8	0.516	22.2	0.444
	B	Fp.b	3880	600	2625	1.48	0.23		**0.020**	22.4	0.448	25.8	0.516	22	0.44	25.7	0.514	23.8	0.476
	C	Fp.ce - Fp.e							**0.050**	22.3	1.115	25.7	1.285	22	1.1	25.8	1.29	22.2	1.11
		Fp.ce	3880	2630	2625	1.48	1.00	0.050											
	D	Fp.df - F.f							**0.050**	22.6	1.13	25.8	1.290	22	1.1	25.7	1.285	23.8	1.19
		Fp.df	3880	2630	2625	1.48	1.00	0.050											
	E	Fp.ec1c2 - Fc1c2+Fc3							**0.025**	25	0.625	25.8	0.645	22.3	0.5575	25.4	0.635	25.2	0.63
		Fp.ec1c2	3415	2050	2625	1.30	0.78	0.045											
		Fc1	815	2050	2625	0.31	0.78	0.015											
		Fc2	3415	500	2625	1.30	0.19	0.010											
		Fc3	815	500	2625	0.31	0.19	0.005											
	F	Fp.fd1d2 - Fd1d2+Fd3							**0.025**	24	0.6	26.2	0.655	21.6	0.54	25.6	0.64	25.4	0.635
		Fp.fd1d2	3415	2050	2625	1.30	0.78	0.045											
		Fd1	815	2050	2625	0.31	0.78	0.015											
		Fd2	3415	500	2625	1.30	0.19	0.010											
		Fd3	815	500	2625	0.31	0.19	0.005											
Back wall	A	Fp.a	2625	2630	3880	0.68	0.68		**0.030**	23.9	0.717	23.7	0.711	23	0.69	24.9	0.747	25.4	0.762
	B	Fp.b	2625	600	3880	0.68	0.15		**0.010**	24.5	0.245	24.2	0.242	23	0.23	25.2	0.252	25.6	0.256
	C	Fp.c	2625	2630	3880	0.68	0.68		**0.030**	23.9	0.717	23.7	0.711	23	0.69	24.9	0.747	25.4	0.762
	D	Fp.d	2625	600	3880	0.68	0.15		**0.010**	24.5	0.245	24.2	0.242	23	0.23	25.2	0.252	25.6	0.256
Left wall	A	Fp.a - Fp.g							**0.017**	22.5	0.3825	23.5	0.400	22.9	0.3893	23.8	0.4046	24.3	0.4131
		Fp.a	3880	600	2625	1.48	0.23	0.022											
	G	Fp.ga1 - Fa1							**0.005**	23.5	0.1175	24.3	0.122	23.2	0.116	26.2	0.131	24.5	0.1225

		Fp.ga1	3492	600	2625	1.33	0.23	0.020											
		Fpa1	2492	600	2625	0.95	0.23	0.015											
	B	Fp.b	3880	600	2625	1.48	0.23		0.020	22.5	0.45	23.5	0.470	22.9	0.458	23.8	0.476	24.3	0.486
	C	Fp.c - Fp.e							0.047	22.5	1.0575	23.5	1.105	22.9	1.0763	23.8	1.1186	24.3	1.1421
		Fp.c	3880	2630	2625	1.48	1.00	0.054											
	D	Fp.d - Fp.f							0.044	22.5	0.99	23.5	1.034	23.2	1.0208	23.8	1.0472	25.2	1.1088
		Fp.d	3880	2630	2625	1.48	1.00	0.054											
	E	Fp.ec1 - Fc1							0.007	23.5	0.1645	24.3	0.170	23.2	0.1624	26.2	0.1834	24.5	0.1715
		Fp.ec1	3492	2050	2625	1.33	0.78	0.045											
		Fc1	2492	2050	2625	0.95	0.78	0.038											
	F	Fp.fd1d2 - Fd1d2+Fd3							0.010	23.4	0.234	25	0.250	23.2	0.232	25.8	0.258	25.2	0.252
		Fp.fd1d2	3395	2050	2625	1.29	0.78	0.045											
		Fd1	795	2050	2625	0.30	0.78	0.015											
		Fd2	3395	1250	2625	1.29	0.48	0.030											
		Fd3	795	1250	2625	0.30	0.48	0.010											
Floor	A	Fp.a	2625	3880	600	4.38	6.47		0.100	23.5	2.35	24	2.400	22.5	2.25	24.9	2.49	25.5	2.55
	B	Fp.b	2625	3880	600	4.38	6.47		0.100	23.5	2.35	24	2.400	22.5	2.25	24.9	2.49	25.5	2.55
	C	Fp.c	2625	3880	600	4.38	6.47		0.100	23.5	2.35	24	2.400	22.5	2.25	24.9	2.49	25.5	2.55
	D	Fp.d	2625	3880	600	4.38	6.47		0.100	23.5	2.35	24	2.400	22.5	2.25	24.9	2.49	25.5	2.55
Ceiling	A	Fp.a	2625	3880	2630	1.00	1.48		0.045	23.8	1.071	24.5	1.103	23	1.035	25.4	1.143	26.3	1.1835
	B	Fp.b	2625	3880	2630	1.00	1.48		0.045	23.8	1.071	24.5	1.103	23	1.035	25.4	1.143	26.3	1.1835
	C	Fp.c	2625	3880	2630	1.00	1.48		0.045	23.8	1.071	24.5	1.103	23	1.035	25.4	1.143	26.3	1.1835
	D	Fp.d	2625	3880	2630	1.00	1.48		0.045	23.8	1.071	24.5	1.103	23	1.035	25.4	1.143	26.3	1.1835
MRT for a seated student in the centre of the classroom using the surfaces temperatures and the angle factor											**25.34**		**26.32**		**24.38**		**26.89**		**27.20**

1. ASHRAE. *ASHRAE 2005 Fundamentals Handbook*. SI edition ed; 2005.

Appendix 10: Mahoney tables' results

Table 1: Results of al-Minya climatic analysis using Mahoney tables

Data Entry (al-Minya, Egypt)												
Months	JAN	FEB	MAR	ABR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Average of the Maximum temperature	21.5	25.0	29.3	35.9	41.3	42.1	38.7	40.1	38.1	38.8	31.0	27.0
Average minimum temperatures	3.1	1.3	6.6	9.2	13.9	14	17.9	20.5	18.8	16.6	10.6	3.7
Relative humidity maximum	80%	70%	61%	50%	44%	49%	58%	56%	60%	66%	66%	76%
Relative humidity minimum	46%	38%	34%	24%	22%	25%	29%	29%	34%	37%	45%	49%
Rain (mm Hg)	0	0	0	0	0	0	0	0	0	0	0	0
Heat stress												
Months	JAN	FEB	MAR	ABR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Day	Cold	Comfort	Comfort	Heat	Heat	Heat	Heat	Heat	Heat	Heat	Heat	Comfort
Night	Cold	Cold	Cold	Cold	Cold	Cold	Comfort	Comfort	Comfort	Cold	Cold	Cold
Indicates												
Months	JAN	FEB	MAR	ABR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
H1 Ventilation essential (heat and humidity)												
H2 Ventilation desirable (heat and humidity)												
H3 Protection against rain												
A1 thermal inertia	X	X	X	X	X	X	X	X	X	X	X	X
A2 Sleeping outside							X	X	X			
A3 Problems with cold	X											
Recommendations Architectural												
Plan mass												
Compact plans with interior courtyards												
Space between buildings												
Compact plans												
Air circulation												
Circulation air useless												
Dimensions of openings												
Small, 15 to 25% of the surface of the walls												
Protection for openings												
Protection against sunlight												
Walls												
Construction heavy for strong thermal inertia; jet lag more than 8 hours												
Roof												
Construction heavy for strong thermal inertia; jet lag more than 8 hours												
External spaces												
Space for sleeping in the open												

Publications

Paper 1:
The environmental performance of classrooms: A case study from El-Minya Governorate, Egypt

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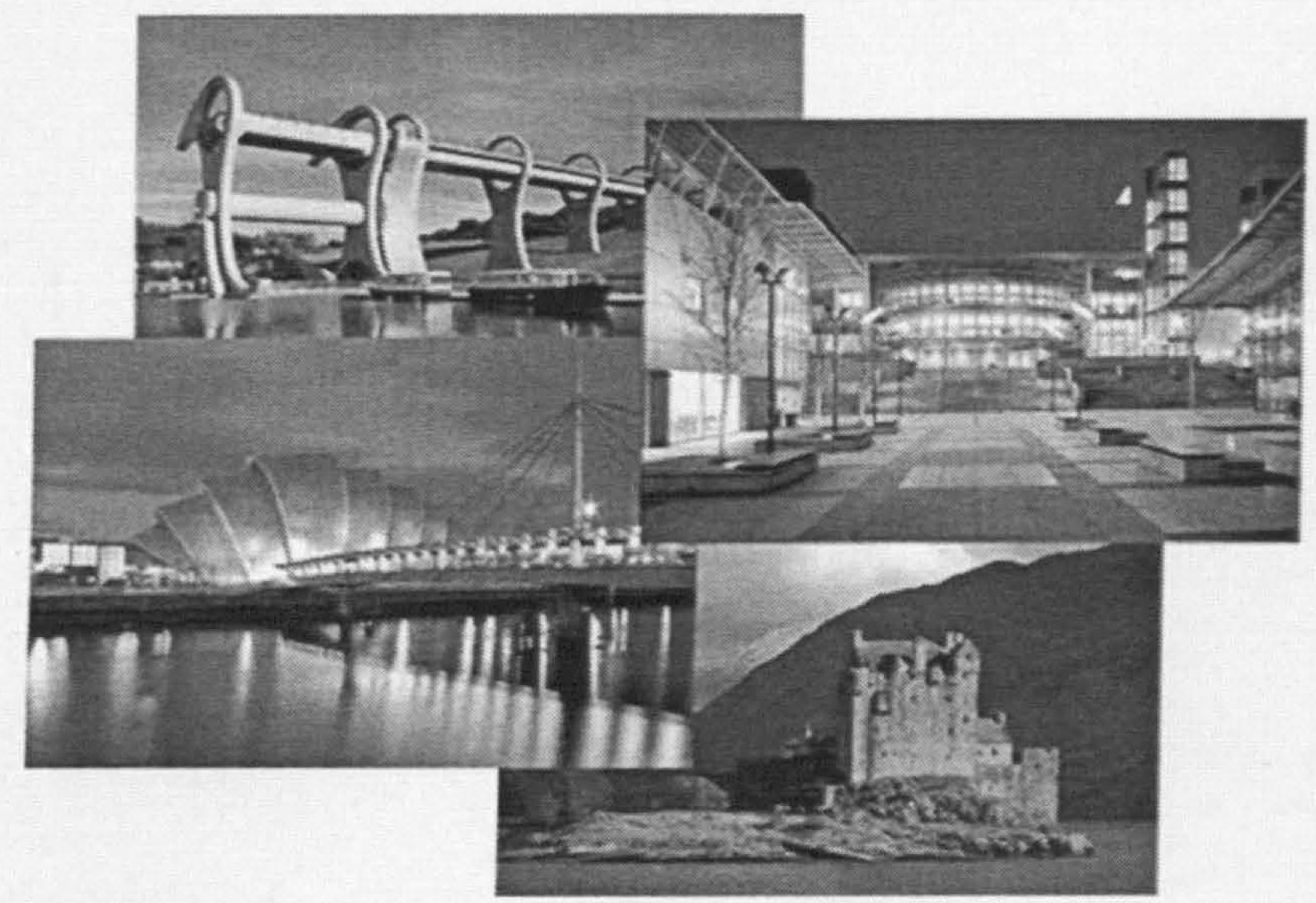

Edited by
Prof. Charles O. Egbu
Michael K.L. Tong

ISBN 1-903661-82-X

Glasgow Caledonian University · CIB · In partnership with Scottish Enterprise Glasgow · CIOB · Blackwell Publishing · apm · ARCOM

THE ENVIRONMENTAL PERFORMANCE OF CLASSROOMS: A CASE STUDY FROM EL-MINYA GOVERNORATE, EGYPT

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Abstract: The provision of primary schools in Egypt is one of the demanding issues facing the Egyptian government since the earthquake of 1992. In the aftermath of the quake the government has designed a substantial number of primary schools around the country in an attempt to replace schools lost in the disaster. This paper presents the results of an investigation into the environmental performance of classrooms inside eighteen government schools from the El-Minya Governorate. Interviews were conducted with the pupils and the staff of the schools. The authors of the present paper believe that the environmental performance of these classrooms could be better addressed than at present. Accordingly, this investigation was essentially to establish the roots of the problems and to identify approaches for further investigation. One problem is that schools of typical design have been built in varying climatic regions of the country. The results suggest that the majority of pupils and teachers in all case studies suffer from thermal and visual discomfort during much of the academic year inside the classrooms.

Keywords: Egypt, Environmental performance, Schools

1. INTRODUCTION

This paper presents the findings of a pilot study which is part of an extend research project running at Dundee School of Architecture investigating the environmental performance of government schools in Egypt. The main aim of this pilot study was to identify environmental problems inside classrooms of government primary schools. This study focused on problem identification. Proposal for addressing the environmental problems found will be the focus of the next part of the research; it is not covered here. Schools investigated in this work are those designed and built by the Egyptian General Authority of Educational Buildings (GAEB) after the earthquake of 1992. Eighteen case studies from El-Minya Governorate were surveyed. A total number of 108 classroom occupants were interviewed to assess their subjective response.

2. BACKGROUND

2.1 Location of the study

Egypt occupies the Northern corner of Africa. It is bounded by the Mediterranean Sea from the North, the Red Sea from the East, Libya from the West and Sudan from the South as shown in Figure 1. The total area of the land is just over one million Km^2, only 4% of this area is inhabited. Egypt is divided into 26 administrative units called 'Governorates'; each is divided into several towns. Each town includes one city and several villages. Egypt lies in the dry equatorial region except its northern areas which lies in the moderate warm region with a climate similar to that of the Mediterranean. On average the climate is warm and dry in summer and moderate with limited rain fall that increases at the coast in the winter. The climate in Egypt is influenced by several factors including its geographical location, topography, general system of atmospheric pressure and the water surfaces surrounding it. The country is divided into seven climatic design regions; the largest is the desert region. El-Minya Governorate is indicated on the map.

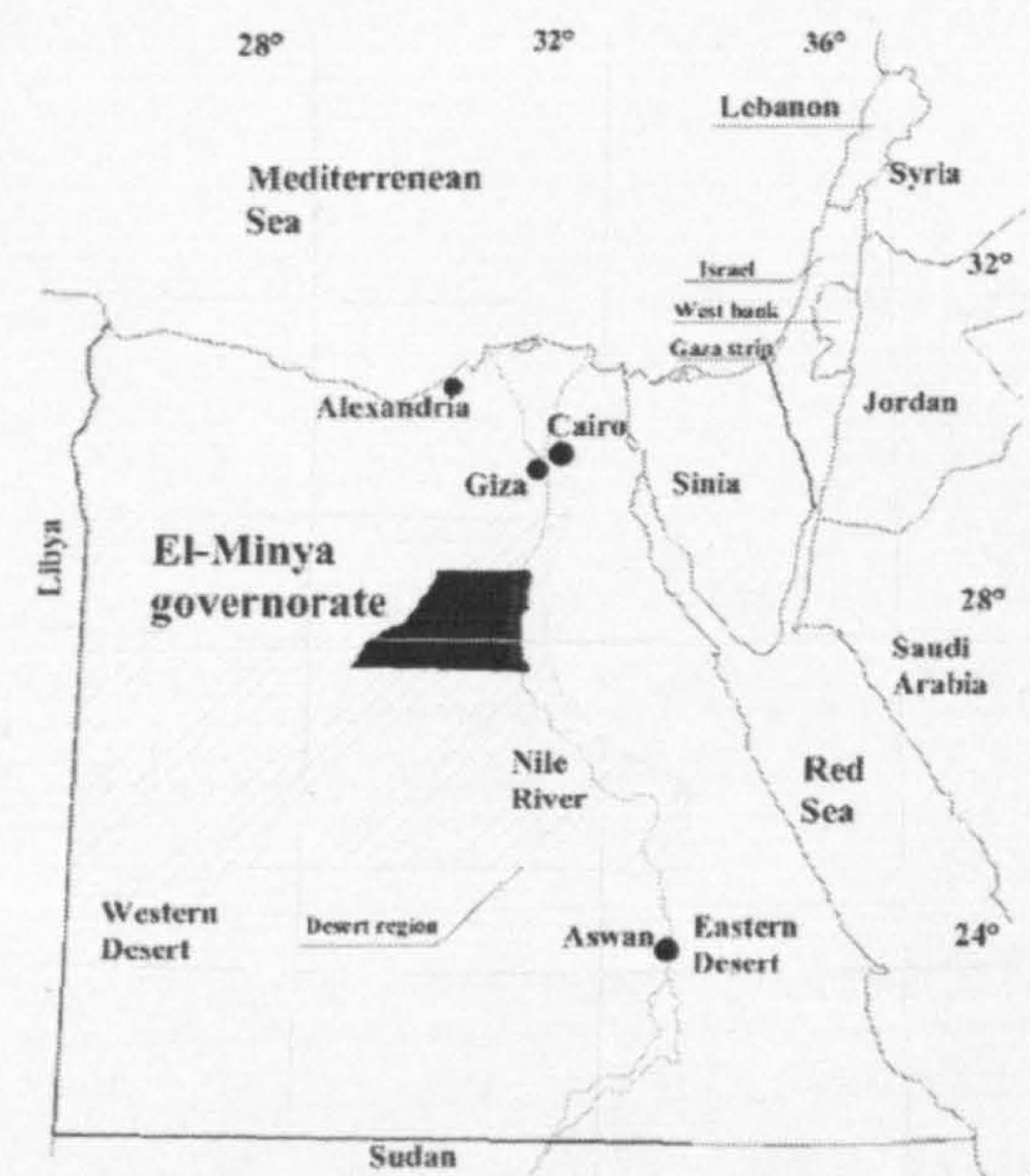

Figure 1: Egypt boarders and El-Minya Governorate location

All the case studies are located in El-Minya Governorate, which lies in the heart of Egypt and is bounded by Bani-Suef Governorate from the north, the Eastern Desert from the east, the Western Desert from the west and Assuit Governorate from the south (Figure 1). Its total area is 56,587 Km^2 and consists of nine towns, each has a centre called city. Each town is divided into several administrative sectors; each includes a number of villages and has its council. The total number of villages in the governorate is 346 (IDSC; 1999).

2.2 Primary schools in Egypt

Figure 2 illustrates the growth of public school numbers in Egypt. It can be seen from this figure that the number of schools has jumped twice since the 1950s. The first time was at the end of 1952 when the Revolution brought about - at that time what was considered - a host of achievements that included an increase in the number of schools (IDSC; 2005). The second was after the 1992; the government had to build many schools to replace those destroyed by the major earthquake of that year (GAEB; 1994).

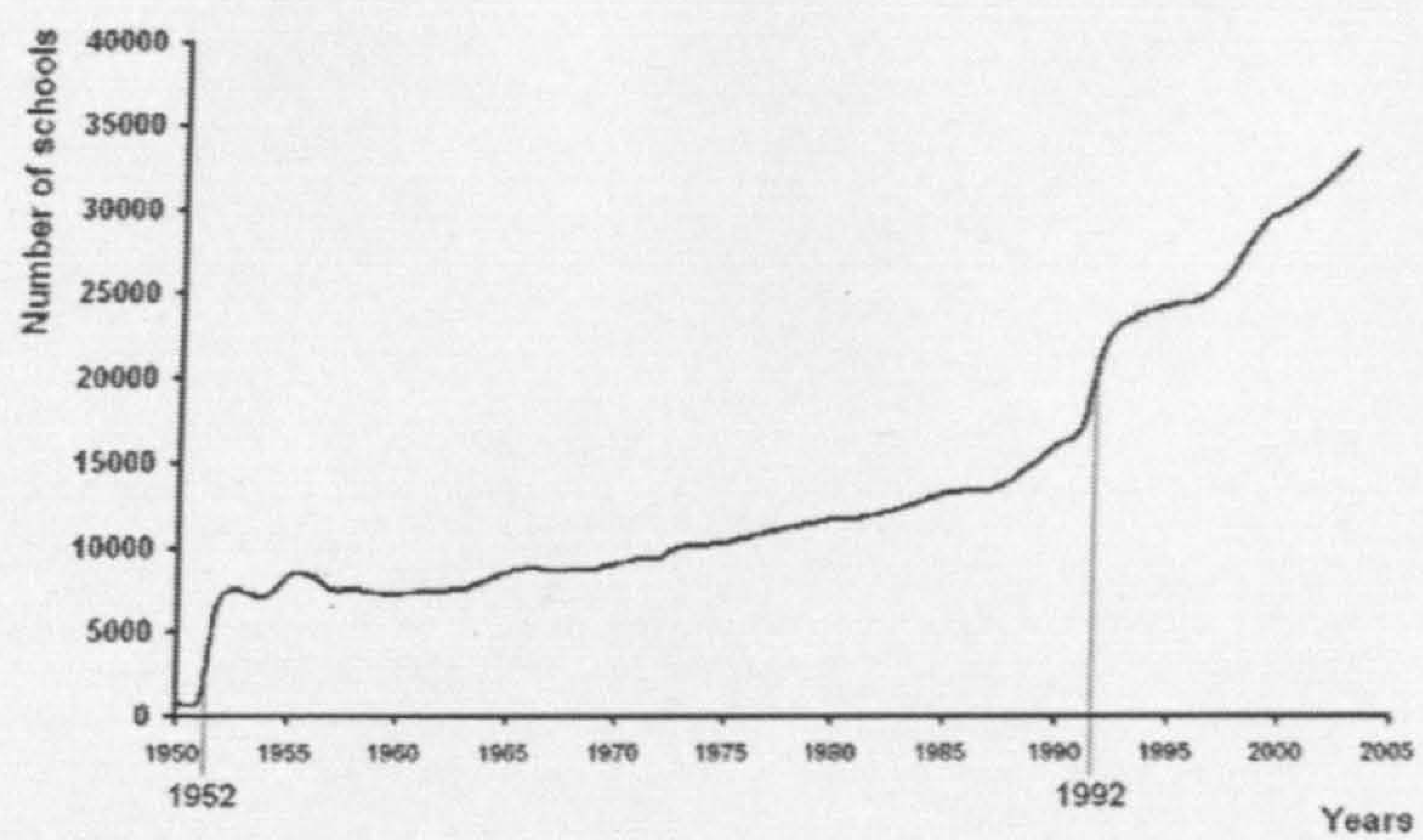

Figure 2: Schools number in Egypt from the year 1951 to 2005, after the Egyptian Ministry of Education (Ministry of Education; 2005)

2.3 Research problem

In 1992 Egypt was hit by an earthquake that registered 4.7 on the Richter scale and was followed shortly by an aftershock measuring 3.8 (Farag; 2002). This disaster affected 3964 buildings including a considerable number of schools increasing the demand for primary schools which was already high pre 1992.

Another factor that contributed to the increase in this demand was the changes that took place in the education system. Primary education in Egypt has traditionally had six levels. In the academic year 1988/1989 this was reduced to five levels (Fergany; 1994), but in 2004/2005 the sixth level was reintroduced. In 1999 the policy was to build bigger primary schools to cope with the increased numbers of pupils expected by the academic year 2004/2005. Until the academic year 2004/2005 this problem was not solved completely; 14% of the primary schools in Egypt did not have enough classrooms to accommodate the pupils in the sixth level who started school at 1999. Accordingly pupils had to use the classrooms of nearby preparatory schools (Ebrahim; 2004). This greatly affected the educational process.

The government established the Egyptian General Authority of Educational Buildings (GAEB) to be responsible for designing, building and maintaining new schools around the country to deal with the new demands before and after the earthquake. The authority designed several prototypes for all the education stages including primary schools. The number of classrooms in each prototype varied from six classes to forty three classes per school (GAEB; 2004).

The problem at the heart of the present research is that the same basic school designs were repeated all over the country without taking into consideration the varying effects of climate on the environmental behaviour of such schools. In previous work Gado (Gado; 2001) proved that the implementation of this design policy using the same design in different parts of Egypt in the housing sector produced climatically problematic dwellings. It is expected that the same will be true for the school buildings. Investigating this problem is very important. The majority of children up to the age of twelve in Egypt spend from 15% to 22% of their time in mainstream schooling.

2.4 Previous work

Many attempts had been made in the past to approach government schools in Egypt. However, the majority of these researches approached this issue from social, educational, economical or theoretical points of view and very few looked into their environmental design. Toulan (Toulan; 1982, Toulan; 1989) focused on the conceptual design of primary schools. Abdalla (Abdalla; 1994) studied the impact of new educational tools on both conceptual design and human dimensions. Shalabi (Shalabi; 1996) and El-Mola (El-Mola; 1999) investigated the integration of the educational process with the architectural design process. El-Nashar (El-Nashar; 1998) studied the physical setup of the educational spaces and its impact on children's behaviour. Noufal (Noufal; 1998) studied factors affecting schools built in overcrowded districts of Cairo. El-Hefnawy (El-Hefnawy; 2002) investigated health and safety issues in educational buildings especially in primary and preparatory schools (fundamental schools). The Housing Building and Urban Planning Research Centre (HBUPRC) under the supervision of Ministry of Education conducted a research aiming to formulate guidelines for designing fundamental schools in Egypt (HBURC; 1987). The study looked into the quality of educational spaces, their occupants' responses and their environmental performance. A survey was conducted that included twenty fundamental schools in Greater Cairo and a questionnaire was distributed to teachers the head teachers. The most recent research that was found (IERS; 1992) during this review looked into the conceptual design of fundamental schools, landscape design, materiality, and solar shading.

From previous notes, it can be seen that only a few studies have touched on the environmental performance of primary schools in Egypt. The majority of work has been oriented towards other aspects of primary schools design. This gap in the body of knowledge was identified and is being approached in this extended research project.

3. RESEARCH METHODOLOGY

Egypt is divided into seven climatic design regions the largest is the desert region. The climate of El-Minya Governorate represents the typical climate of this region. Accordingly it was decided to choose all the cases studies from this governorate.

3.1 Case studies

The study chose to investigate primary schools as these represents just over 44% of all the governmental schools in Egypt (Education; 2005). In this work three prototypes designed by GAEB were investigated; the six classes prototype (T6), the twelve classes prototype (T12) and the eighteen classes prototype (T18). These three prototypes represent 80% of the primary schools built after the earthquake of 1992 (GAEB; 2004). A total number of eighteen primary schools were used in the survey; five T6, seven T12, and six T18 schools. These case studies are located in seven different towns of El-Minya Governorate. Out of the eighteen schools twelve were built in rural contexts (villages) and six were built in urban areas (city).

3.2 Method of data collection

The present study has used semi-structured interviews to collect data from the occupants of the case studies. This method of data collection is very flexible, suitable for gathering information and people's opinions and motivations (Drever; 1995). More importantly it guaranteed a higher response rate when compared to questionnaires distributed by post. A mixture of closed and open ended questions was used in the interviews. The open ended questions explored the occupants' subjective response to the buildings; while the closed ended questions were used to allow the application of statistical analysis on the results later on in future work. A total number of one hundred and eight occupants were interviewed, 29% of whom were females. Six occupants were chosen randomly from each school, three pupils and three teachers from each.

The aim of the interview with the pupils was to collect data related to their state of comfort inside the classrooms. This work was concerned with thermal, visual and acoustic performance of the classrooms. The interview with the teachers and head teachers aimed to collect data from them regarding both the classrooms and their office rooms. Only the results relating to the classrooms are presented in this paper.

The following three closed ended questions were asked in the interviews:

Q1: Do you feel warm during summer and cold during winter inside the classroom?
Q2: Do you experience any kind of visual discomfort?
Q3: Do you have problem hearing the speaker regardless your location in the classroom?

The interviewees had to choose one answer for each question; either yes, no or not sure. Any difficult expression such as 'visual discomfort' was explained prior to the interviews. The results are presented in the following section.

4. RESULTS AND DISCUSSION

On analyzing the data collected from the interviews it has been found that the majority of occupants of all case studies are not thermally or visually comfortable for most of the academic year. Figure 3 presents this data. 78% of the occupants involved in the interviews were thermally uncomfortable, 58% of them were visually uncomfortable however only 21% reported that the acoustics of the classroom is poor.

83% of the occupants inside T6, 74% inside T12 and 82.35% inside T18 were thermally uncomfortable for most of the time. This could be due to the use of large (2.5m x 1.4m) unshaded south facing single glazed windows. This led to almost half of the children inside the classroom receiving direct solar radiation on their bodies most of the time as shown in the example in Figure 5.

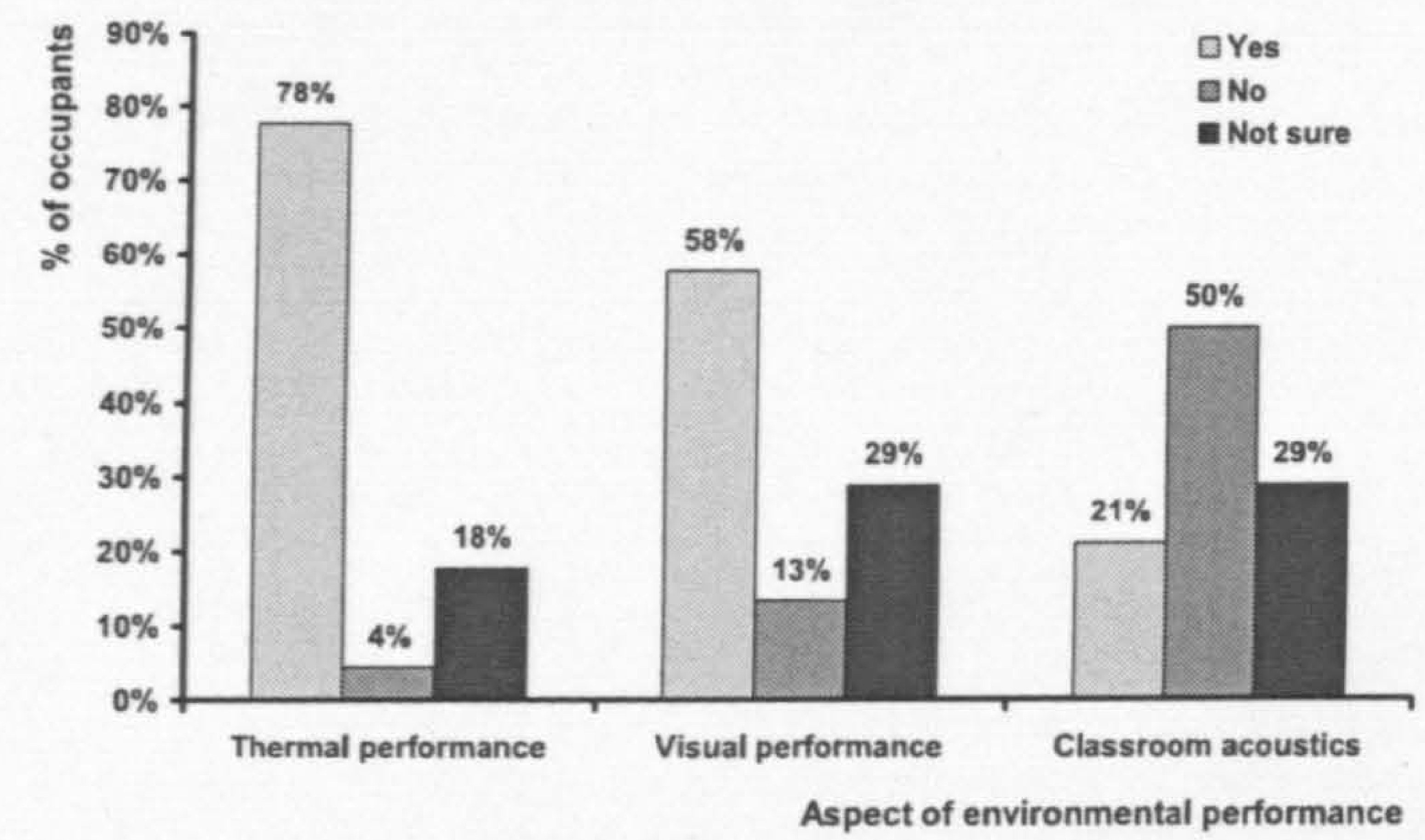

Figure 3: Percentages of occupants feeling discomfort, neutral and who could not answer

This together with air temperatures that range between $35^{o}c$ and $42^{o}c$ in summer will lead to thermal discomfort or even sunstroke in severe cases. The children reacted to this by moving around the classroom, disturbing the educational process and crowding into shaded areas of the room, which made their thermal discomfort worse. In other cases the children and teachers reacted to this situation by sticking sheets of paper on the windows or by painting the windows using dark opaque emulsion as shown in Figure 6 and Figure 7. This led to a severe drop in natural light levels and led to the use of artificial lighting during the day.

Figure 5: Direct solar radiation on the children

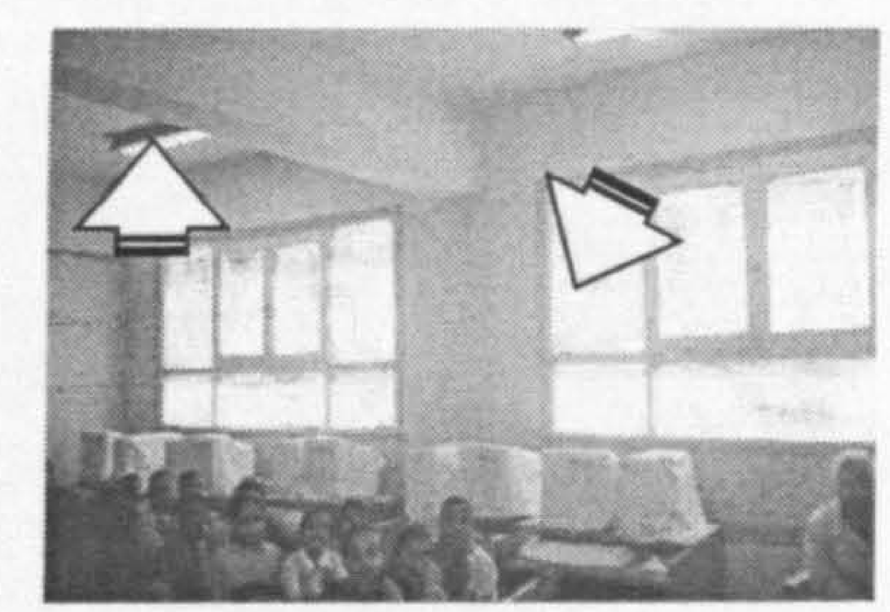

Figure 6: The use of artificial lighting systems during the day

61% of the occupants inside T6 reported that they experience visual discomfort and cannot clearly see the blackboard as shown in Figure 8. 63% of T12 occupants and 47% of T18 occupants reported the same. This is due to the presence of many sources of glare inside the visual field of the children such as; reflections on the blackboard and high levels of light on the working surfaces. This led the occupants to close the windows most of the time leading to stuffy and smelly classrooms due to low levels of air change. It also led as mentioned earlier to low natural light levels and thus artificial lights were being used during the day.

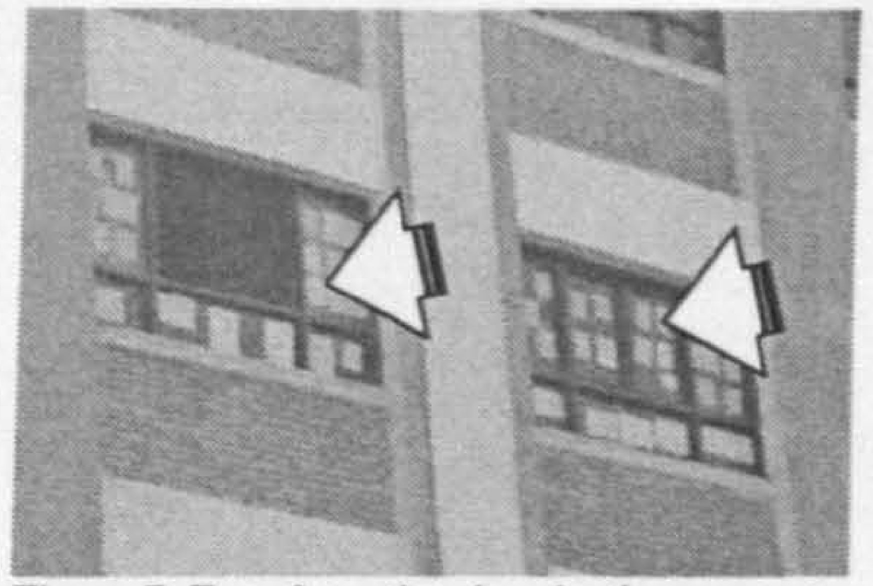

Figure 7: Transformation done by the occupants

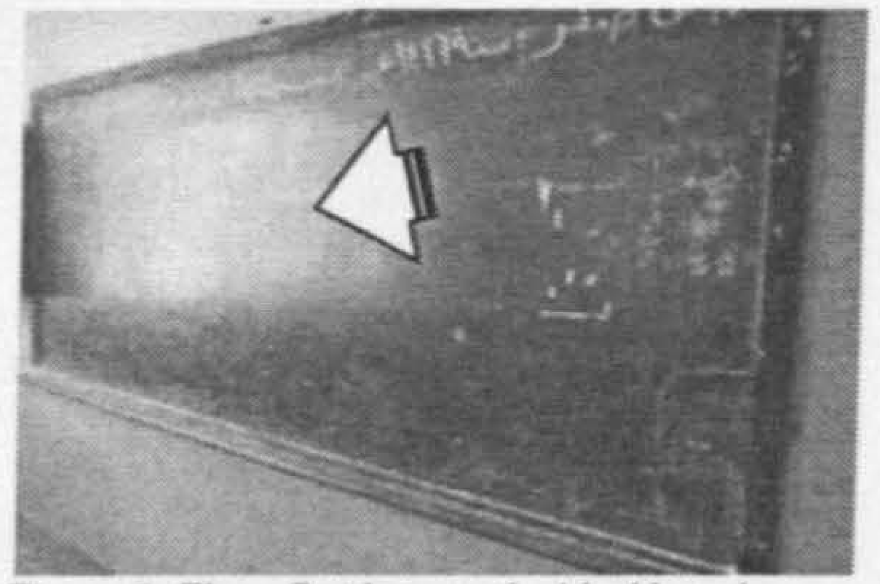

Figure 8: The reflections on the blackboard

As for the acoustic performance it was found that 48% of T6 occupants reported that the acoustics inside the classrooms were poor as they could not normally hear the speaker regardless of their location inside the room. However, only 11% of T12 occupants and 12% of T18 occupants reported the same. This could be due to the large number of pupils inside the same classroom that can reach from 60 to 70 pupils as shown in Figure 9. Another reason could be the high levels of noise coming from external sources especially in overcrowded areas (Figure 10). This can explain why the highest percentage of dissatisfaction was noted in T6 schools since four out of five T6 cases were located in urban contexts while 10 out of the 13 T12 and T18 schools were located in rural contexts where sources of noise are minimal.

Figure 9: Overcrowded classroom

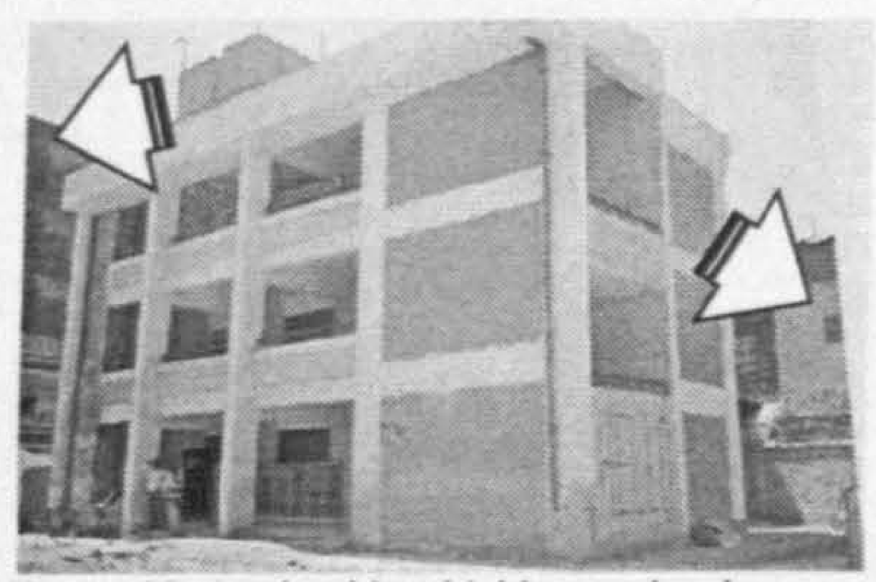

Figure 10: A school in a highly populated area

5. CONCLUSIONS

An interview with 108 occupants inside eighteen government primary schools in El-Minya Governorate was conducted. Three conclusions can be drawn from this work:

1. The majority of the occupants are thermally uncomfortable for most of the time
2. The majority of the occupants are visually uncomfortable for most of the time
3. Less than 25% of the occupants reported that the classrooms acoustics are poor

6. FURTHER WORK

This work will be further developed. A questionnaire will be used to collect data from a larger number of occupants in larger number of case studies. This is important to further confirm the results of this pilot study and identify the most significant environmental problem inside the government primary schools. This will help directing future work in this project. In addition, a number of cases will be monitored during the hottest and the coldest months of the academic year; May and January respectively. This objective measure will confirm the subjective opinion of the occupants. Several passive measures will then be tested using computer modeling in an attempt to enhance the environmental performance of the classrooms. Monitored data will be used to validate the simulations.

7. ACKNOWLEDGMENTS

The authors would like to thank all those who participated in this survey especially the pupils and the teachers. In addition they would like to thank all of the head teachers for their co-operation. They also would like to express their thanks to the Egyptian Ministry of Higher Education for its financial support.

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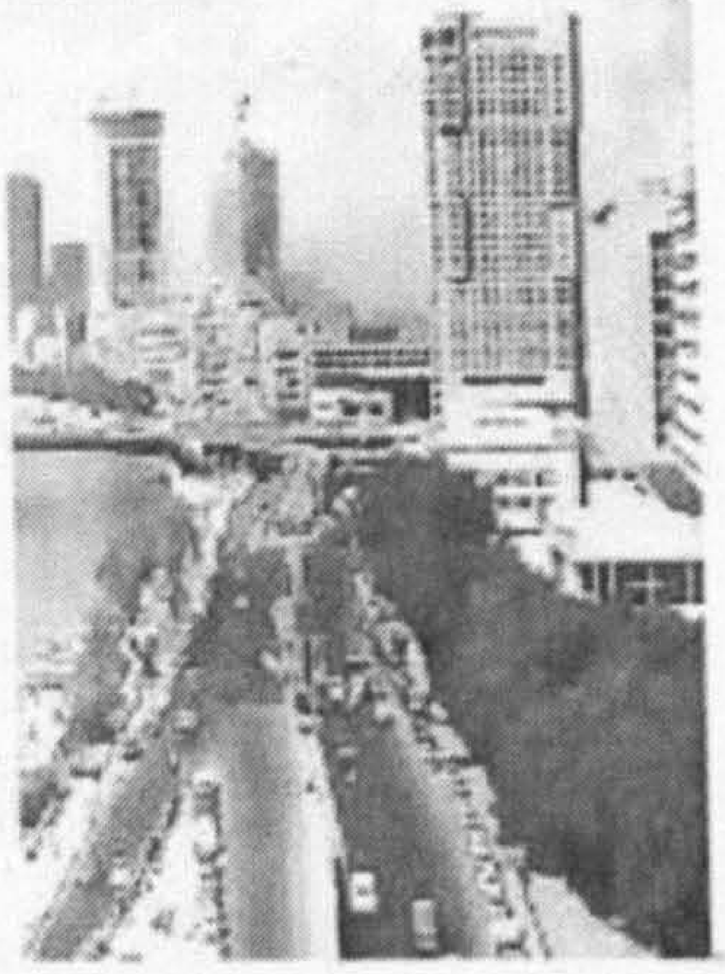
Paper 2:
Application of computer based environmental assessment and optimization tools: An approach for appropriating buildings

A R C H C A I R O 2 0 0 6



Department of Architecture
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ARCHCAIRO 2006

APPROPRIATING ARCHITECTURE TAMING URBANISM IN THE DECADES OF TRANSFORMATION

Under the Auspices of

Prof. Dr. Aly Abdel Rahman Youssef

President, Cairo University

Grand Hyatt-Cairo Egypt
February 21-23, 2006

The use of the terms/conceptions of "Appropriate" and the underlying action "appropriating" in the realms of architecture planning and development in the sixties and seventies of the twentieth century was closely related to technology transfer. The critics questioned the validity of the notion and pointed out the shortcomings of exporting technology, tools and products to developing communities without regard to its settings, natural and manmade; its ability to assimilate or benefit from. The criticism was accompanied by a positive drive calling for "Appropriate Technology", hence advocating a conscious appropriating action directed to technology: tools, process and products to suit the targeted settings/context and communities.

The controversy regarding technology transfer relatively subsided since, but the essence of the emerging conception of seeking the appropriate and appropriating the tools, processes and products continued with the evolving new directions and movements of Post Modernism, Contextuality, Conservation and, Adaptive Reuse, Sustainability and the rest. All acknowledging, respecting, and adhering to design, planning, and development contexts identity and features.

Appropriating design and development endeavours, its intellectual/mental framework, tools and products is becoming a challenge and an urgent need/requirement during the last two decades characterized by open doors & skies, and the free flow of information, thoughts, technology and products.

In other words "Appropriating" or addressing and manipulating of conceptions, tools and products is becoming synonymous to the ability to interact, to evaluate, read, analyze, criticize, experiment and develop; this applies to all civilizations' products including: schools, directions, and theories of architecture, planning processes and building technology, effective development control & practice and conservation of resources (natural and manmade).

From this perspective "Appropriating" architecture and urbanism is a responsibility, both the Developed and Developing communities have to undertake, as it reflects on the various aspects of its development and interaction including building/architecture technology, identity and character, management and planning, development and conservation of resources. It also means setting and definition of references and values, evaluation criteria; all are crucial factors and challenging tasks deeply rooted in architectural and community design processes both in the academic and professional arenas.

This conference invites scholars, researchers, and professionals in the realms of Architecture, Building Science and Technology, Environmental Design and Conservation, Community and Urban Design, Housing and Urban Planning and Management and related areas to address the to address the said issues of Appropriating Architecture and Urbanism in the past and current decades and to participate and contribute to the forthcoming discourse in one or more of the conference themes.

Conference Themes:

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- Architectural criticism: appropriating current and emerging architectural and planning streams of thoughts and theory.
- Environmental systems: appropriating buildings, components and settings.
- Building technology tools and techniques, appropriate and appropriating.
- Community and Urban Design, contextuality and appropriate approaches, references, criteria and determinants.
- Appropriating planning management and development of urban settings and resources.

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- Architectural and Engineering design support center, selected work

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Notification of acceptance (papers)	November 15, 2005
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APPLICATION OF COMPUTER BASED ENVIRONMENTAL ASSESSMENT AND OPTIMIZATION TOOLS: AN APPROACH FOR APPROPRIATING BUILDINGS

ABSTRACT

The main aim of this paper is to devise a research methodology that employs computer based environmental assessment tools, to be used to quantify the effectiveness of passive measures. The use of computer allows the visualization of the unseen environmental attributes in a three dimensional interface, permitting by such more effective understanding of the issues involved in the quantification process. This will also open up this methodology for use by researchers from different professional backgrounds. It also could prove very useful in the identification of the most efficient solutions to the upgrading of the environmental performance of existing buildings. The results of work appertaining to the proposed methodological approach are presented.

1. Introduction

The main aim of this paper is to set out a methodology that can be applied to test the effectiveness of passive measures in buildings during design process or in research projects on designs and existing building. This paper does not claim that this methodology is the sole method to be used to design passive climatic responsive architecture.

However, it can form the general framework to any investigation that aims to design an environmental building or passively improve the environmental performance of already built buildings. The proposed methodology have been developed over time by the first author [1-3] and is intended to be employed in an ongoing research project at Dundee School of Architecture that investigates the environmental performance of governmental primary schools in Egypt [3] focusing on thermal and visual comfort inside classrooms.

2. Research problem

The process of investigating the effectiveness of any environmental design control measure whither passive or active is very complicated. The number of issues related with such investigation is immense, interlinked and overlapped. The following list is an example of the tasks involved in such investigation.

1. Choosing the case study to be employed as a vehicle to test the effectiveness of the measures under investigation
2. Identifying of the environmental problems
3. Setting out the assessment criteria
4. Analyzing the climatic context including; obtaining, designing, modifying, analyzing and visualizing the climatic data
5. Identifying promising passive strategies and measures
6. Quantifying the effectiveness of the proposed passive strategies and measures
7. Results analysis and presentation

In addition, this process involves the use of large number of research tools including; computer analysis tools, manual calculation, interviews, questionnaires, physical modelling etc... The main problem is that the process is usually overwhelmed by time and manpower constrains as well as the financial limitations of any investigation. On the other hand, nothing was found in the literature that sets out a framework for a methodology that can be employed to quantify the effectiveness of passive design measures. A gap in the knowledge was identified which this paper tries to fill by devising a methodology and discussing the main issues involved.

However, the issues involved in the choice of the case study are much dependent on the circumstance of the research project as illustrated in the following examples.

Gado [2] chose to investigate the environmental performance of housing developments in Egypt due to the high demand to cope with the population growth. The author chose a design built by the government not considered to be climatically responsive as it is being repeatedly built in several locations of the country without considering the effect of climate on the internal environments. The case study was chosen from one of the new cities where all the new developments are taking place. A walk-up housing block prototype was investigated as it is the type widely built in Egypt.

Gado et. el. [3] in a recent study investigated the environmental performance of classrooms of primary schools in Egypt. Primary schools was chosen since they represent 44% of all the government schools in the country [4]. The governmental schools have been chosen over private schools since they represent 89% of the total number of schools in Egypt. Three prototypes representing 80% of all primary schools have been elected for the investigation. All the case studies have been chosen from El-Minya governorate that represents the desert climatic region of Egypt; the biggest region in the country. Eighteen case studies in seven towns out of nine were chosen; twelve were built in rural contexts (villages) and six were built in urban areas (cities). This was done to insure that the effect of the microclimate is taken in consideration.

From the above two examples it can be seen that the criteria governing the choice of the case study can be grouped under the following:

1. Demand for the building type
2. Significance of the location
3. Building technology and buildability
4. Climate of the region
5. Context of the case study
6. Microclimate of the site
7. Accessibility to the case studies

3. The proposed methodology

The proposed methodology (refer to Figure 1) is based on the simple known notation of architectural design; target identification, context analysis and design formulation and assessment. It includes three main studies; field study, theoretical study and computer based study. ***The field study*** includes two stages i) choosing an appropriate and representative case study to the research project ii) identifying the environmental problems related to the case study location and building type. ***The theoretical study*** includes two stages i) identifying the environmental design targets ii) formulating potential passive strategies and measures that can be applied to the case study. ***The computer based study*** includes two main stages i) climatic context analysis ii) computer simulation.

4. Field study

The field study is the starting point in the proposed methodology. It begins by choosing a case study. This is essential to achieve the main aim of the investigation as a vehicle is needed to test the effectiveness of the proposed passive measures for a particular building type in a particular location. This is followed by identifying the main environmental problems in terms of thermal comfort and energy performance. This is done through monitoring the subjective response of the case study's occupants using the appropriate tool such as interviews, questionnaires, observation etc. and through measuring the objective response of the interiors using monitoring equipments.

4.1. Choosing case studies

One of the most paramount and critical factor that makes a successful environmental design research project is the proper selection of the case study. Unfortunately, there is no one single definite criteria that govern this process. Choosing a case study includes specifying the building type (schools, housing development etc...), the location of the case study (effect of the microclimate and context of the case study under investigation) and finally specifying the number of cases to be investigated (effect of the sample size on the reliability of the results).

4.2. Identifying the environmental problems

Methods of identifying environmental problems within case studies can be classified under two categories; measuring the occupants' subjective response and measuring the objective response of the built environments. The proposed methodology suggests that measuring the subjective response should be the first step towards identifying the environmental problems. Any attempt to measure the occupant's subjective response and/or the objective response of the environments is faced by lots of obstacles. Measuring the subjective response of the occupants involves data collection, sampling and timing of the survey.

Data collection - There are different methods of data collection. Interviews, questionnaires and observation are the common methods for collecting data from buildings' occupants. Every method has different aims and is based on a different principle. Interviews are more time consuming and require more skills. However, it is very flexible and suitable for gathering information about people's opinions and motivations [5]. On the other hand, it is more suitable to use it with small samples while questionnaires are more suitable to be used with larger samples.

Sampling - In most cases, it is not possible due to time and expenses limitations to test the whole population within a single case study. Consequently, the data have to be obtained from a sample that represents the whole population of the case study. The quality of a peace of research not only stands or falls by the appropriateness of methodology and instrumentation, but also by the suitability of the sampling strategy that is adopted. There are two main methods of sampling; random sampling and a purposive sampling [6]. The main difference between these two methods is that, in the first every one in the population has the chance to be included into the sampling, however in the second the researcher has purposely selected a particular section of the wider population to include in or exclude from the sample. However, it is not possible in all cases to randomly choose the respondents in the sample. For example Al-Shibami [7] used questionnaires to collect data about the thermal conditions from 342 occupants living inside 300 houses on the same day. However, due to cultural restrict in the Yemeni community all the

respondents in his sample where men biasing by such his results. In another case Gado et el. [3] interviewed school occupants in 18 different schools. It was not possible to balance the number of females to males and only 29% of the sample was females. This was inevitable due to the low rate of female attendance.

5. Theoretical study

The theoretical study aims to set out the environmental design targets to be used latter to assess the performance of the case study's spaces. It also aims to formulate the potential passive strategies and measures that can be used to enhance the environmental performance of the case study under investigation.

5.1. Environmental design targets identification

This methodology employs thermal comfort and energy efficiency as environmental design targets. The effectiveness of the proposed measures is determined according to its ability to passively achieve thermal comfort by using minimum amount of energy possible.

This methodology uses two ways to identify the environmental design targets i) through environmental design codes ii) through analysing the climatic context. Environmental design codes such as CIBSE environmental design guide A [8] sets out environmental design targets for the United Kingdom. For other locations the relevant codes should be consulted and if not found or one is in doubt, design targets should be identified by other means. Several empirical and analytical approaches were employed through the last decade to develop indices capable of predicting thermal comfort through analysing the climatic data. Field survey is an example of empirical studies where the physical characteristics of the environment are related to the subject's thermal sensation in order to find a relationship. Humphreys adaptive thermal model is an example of models devised empirically. On the other hand, analytical approaches are based on experiments made in controlled environments to assess thermal sensation of individuals. Fanger's Predicted Mean Vote (PMV) and Gagge's Standard Effective Temperature (SET) used by the American Society of Heating, Refrigerating and Air-Conditioning Engineers are good examples of the analytical approaches.

5.2. Formulating potential passive strategies and measures

The proposed methodology uses three methods to formulate potential passive strategies and measures that can be applied to the case study to improve its environmental performance. The first is part of the theoretical study and the second two are parts of the computer-based study.

Analytical investigation into methods of dealing with climatic used by vernacular and contemporary architecture within the context of the case study. This methodology adopts Hassan Fathy classification of vernacular methods of dealing with climate. Fathy classified these methods according to the main three climatic elements that affect the microclimate of buildings: sun, ventilation and humidity [9].

Weather Tool software that uses Svszokolay method of Psychrometric analysis is used to plot the hourly climatic data points on a Psychrometric chart. An overlay is drawn representing the comfort zone before and after using any of six passive strategies including passive solar heating and thermal mass. Then the number of points within each zone is counted. The results are then presented in the form of a graph showing the effect of using each strategy as a percentage of increased human comfort at each month and the overall effect for the whole year. Any number of strategies can then be combined to reach the most effective combination of passive strategies.

Computer-based version of Mahoney tables developed at the department of Housing Development & Management at the School of Architecture, Lund University [1] is used to suggest passive strategies.

6. Computer based study

This study includes two main tasks; the climatic context analysis and computer simulation. In order to analyse the climatic

[1] www.hdm.lth.se/TRAINING/Postgrad/AEE/index.htm

context a suitable set of climatic data of the location under investigation is needed. The proposed methodology employs a method of designing hourly climatic data to be used in case of actual data is not available. On obtaining the hourly climatic data, Weather Tool software is used to visualise and analyse the data in order to propose potential passive design strategies as discussed in section 5.2. Having identified the potential passive measures and strategies through the theoretical analysis and climatic context analysis, a set of computer simulation software is used to simulate the environmental performance of the case studies. Results are then analyzed using a spreadsheet to present the effectiveness of the proposed measures and strategies under investigation.

6.1 Climatic context analysis

6.1.1 Obtaining climatic data

To conduct any investigation into the environmental performance of buildings, comprehensive climatic data is needed to analysis the climatic context of the case study and to carry out the calculation. In most cases, hourly climatic data is very expensive and hard to find. Gado [2] devised a methodology for designing a comprehensive and yet representative hourly climatic data to be used in computer simulation. This methodology depends mainly on utilizing synthesised climatic data generated by Meteonorm software[2] which interpolates the climatic data needed for a certain location using the information from the nearest meteorological station to this location. Interpolated data is then rescaled using the 'Synthesis Data' feature of Weather Tool software[3]. This feature is used to superimpose accurate monthly averages on the synthesised data. This feature was developed by Dr. Andrew Marsh (author of Ecotect), and the first author in 2001.

[2] www.meteotest.ch/en/firma
[3] www.squ1.com/software/ weather-tool/features.html

6.1.2. Visualization and analysis

There are several computer-based tools on the market that can be used to analyse climatic data. The majority of the available software is limited to a single function such as plotting psychometric charts. Example of such tolls is HDPsyChart [4] and CYTSoft [5]. In addition, they are not intended to architectural use but rather oriented towards thermodynamics-related industries such as HVAC to help solving problems involving moist air. Most of the metrological offices have there own computer software, which are not commercially available.

The proposed methodology utilizes Weather Tool to visualize and analysis both monthly and hourly climate data. It recognizes a wide range of international weather file formats such as fixed format weather files, separated value files, and linear row data files. In addition, it allows the user to specify customized data import formats from ASCII files allowing by such the use of a wide rang of climatic data files. Moreover, it can import energy plus climatic data files; a widely used free energy simulation software. It can visualize data in a wide range of 2D and 3D formats. It can also perform several analysis functions including assessing the relative potential of different passive design strategies and measures and accurately determining the optimum orientation for specific building design criteria.

6.2. Computer simulation

The effectiveness of the suggested passive measures and strategies obtained from the literature review and climatic data analysis is quantified in this stage. The case study is spatially analysed and all the analysis parameters are defined. Using a computer simulation tool, the temperature of the case study zones is simulated and results are analysed. Proposed measures are evaluated by comparing the environmental performance of the spaces before and after introducing the proposed measure to the case study one at a time in terms of

[4] www.chempute.com/psychro.htm
[5] www.cytsoft.com

thermal comfort and energy consumption.

Spatial analysis and boundary conditions

Before conducting the computer simulation, it is essential to conduct spatial analysis for the case study to identify the thermal zones, zones geometry, identify the adjacent zones to be included in the analysis etc...

Simulation

The first step towards achieving this task is to simulate the case study as built to form what is called the base case. The proposed measures are then tested by introducing each one to the base case one at a time and its impact on the internal environment is modelled. It is proposed that both free running and air-conditioned scenarios are modelled to enable quantifying the effectiveness of the tested measures in terms of both thermal comfort and energy efficiency.

The methodology proposes using whole-building analysis software such as ESP-r, IES, DesignBuilder, ArchiPHYSIK or Ecotect instead of using a combination of several simulation packages such as using Radiance, EnergyPlus and FLOVENT to conduct lighting, energy and air flow analysis. This will allow constructing and using a single building model saving time and effort and increasing by such the efficiency of the simulation process. The choice of the tool depends on the level o accuracy needed and the time limitation of the project as well as the level of user expertise. This methodology suggests to use Ecotect for several reasons. Its user-friendly interface allows constructing 3D models. It can import CAD models from AutoCAD and 3D studio. In addition, results are presented in a clear way that facilitates the communication between the researchers and between members of the design team and the clients. It can export and import data to and from more sophisticated simulation tools such as Radiance, EnergyPlus and HTB2 allowing by such conducting more in-depth analysis if needed. Ecotect has especial environmental analysis features such as solar access and exposure analysis, solar shading design, overshadowing calculation, and can assess the effect of space geometry on room acoustics etc... More importantly, Ecotect incorporates Humphreys' adaptive algorithms [10] allowing by such to take in consideration the adaptive action taken by building occupants. This feature, were introduced to the program by Marsh the author of Ecotect and Gado the first author of this paper [2]. Ecotect is used in this methodology to calculate hourly internal temperatures and heating and cooling loads within each zone using the admittance method.

Data analysis

The simulation output is fed into a spreadsheet to calculate the percentage of benefit or loss due to the use of each measure. This is achieved by comparing the simulation results of the base case to the results of the base case with each measure introduced to it. The result of such comparison being positive means benefit and being negative means loss. In order to do so, four spreadsheets are needed; two for the base case results (one for free running and one for air-conditioned case) and two for the base case plus each measure (one for free running and one for air-conditioned case). Using the output of these analysis two sets of graphs can be plotted to illustrate the benefits and losses due to the use of each measure in the form of a percentage of change, either benefit or loss.

7. Further work

This methodology is under continuous development at Dundee School of Architecture, UK. It is planned to test this methodology in several ongoing research projects that investigate the use of passive design measures in dwellings and schools in Egypt. Further development to this methodology will be published in the Architectural Research Quarterly Journal published in the UK.

8. Acknowledgment

The authors would like to acknowledge the Egyptian Ministry of Higher Education for the scholarship given to the second author and the Egyptian Education and Culture Bureau in London for their effort in managing the scholarship.

9. Figures and graphs

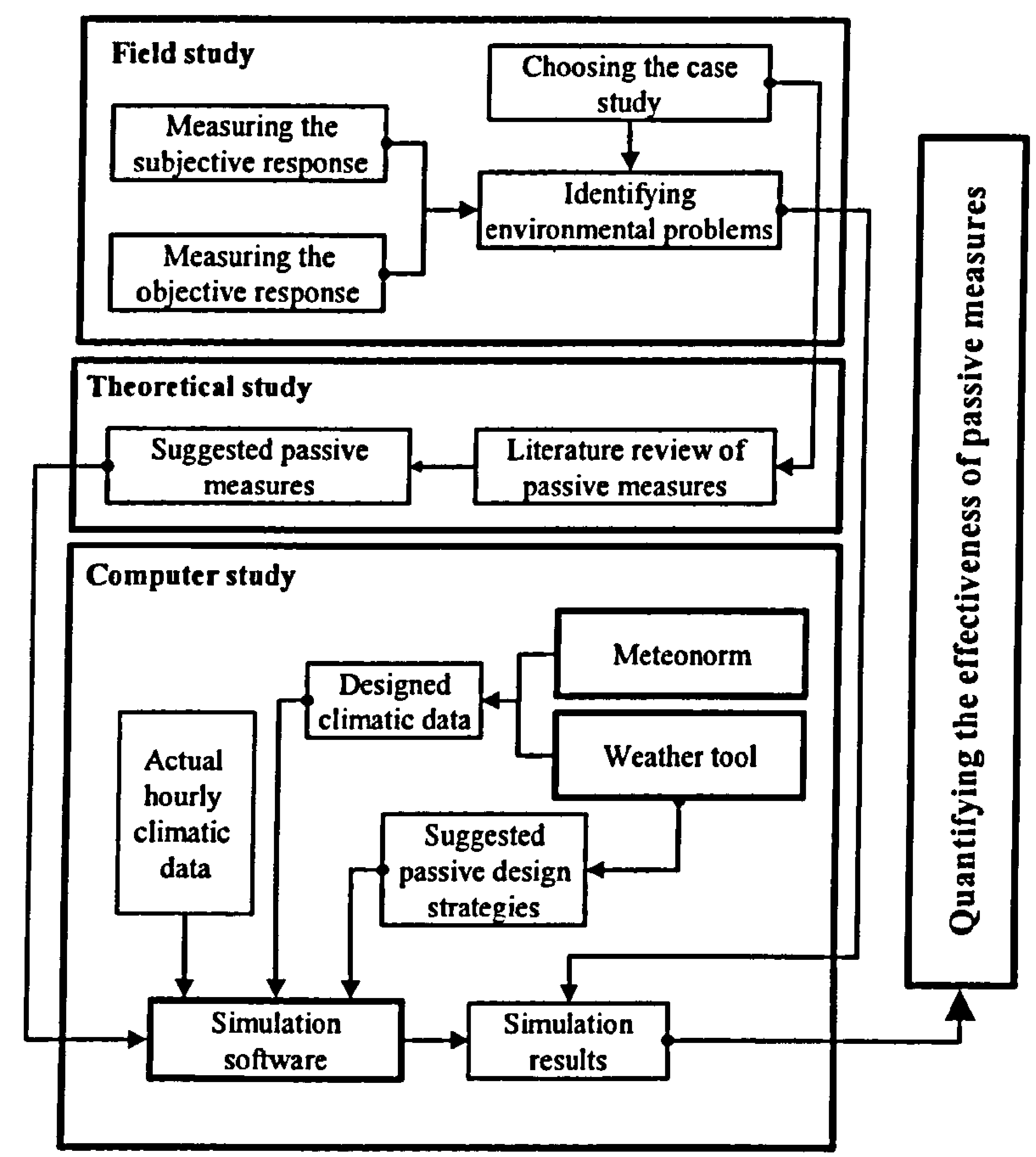

Figure 1: The proposed methodology

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Paper 3:
Assessment of thermal comfort inside primary governmental classrooms in hot-dry climates
Part 1 – A case study from Egypt

SUEMoT

SUE-MoT Conference 2009

Second International Conference on Whole Life Urban Sustainability and its Assessment

Loughborough, UK *22-24 April 2009*

Conference Proceedings

Editors: M. Horner, A. Price, J. Bebbington, R. Emmanuel

First published in Great Britain in 2009 by Loughborough University

Typeset in Warnock Pro using Adobe InDesign, XeLaTeX and PDF::Reuse by James Sutherland, University of Dundee

All papers were double-blind reviewed.

ISBN-13 978 0 947974 81 7

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Assessment of thermal comfort inside primary governmental classrooms in hot-dry climates Part I – a case study from Egypt

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The provision of primary schools in Egypt is one of the demanding issues facing the government since the earthquake of 1992. In the aftermath of the quake, the government has built a substantial number of primary schools around the country in an attempt to replace schools lost in the disaster. This work aims to investigate the environmental performance of governmental primary schools in Egypt as an example of a hot-dry climate. The study is presented in two parts. In this paper the results of the subjective assessment of the case studies is discussed. Work was done on three stages; the first and the second investigated the environmental problems inside 19 case studies in al-Minya Governorate. The third stage further investigated the thermal comfort of occupants inside three case studies. The results suggested that the majority of the occupants were thermally discomfort for most of the time during the academic year. In the second part, the results of a field study aiming to objectively assess the thermal performance of a small sample of classrooms were discussed. This study will inform future work investigating the potential of passively enhancing the thermal comfort of occupants inside primary governmental classrooms in Egypt.

Keywords: assessment, building, environmental assessment

1. Introduction

Schools can act as regeneration catalysts by contributing to the development of the area around them. This was evident through the project of the 100 schools initiated by the Government in some areas of Greater Cairo, where the school buildings were refurbished and were opened to the community boosting by such the sense of pride of both the children and the society.

Internal environmental quality (IEQ) of schools can significantly affect the occupant's perception of space as well as their health, performance, physical comfort and mental wellbeing. Unhealthy classrooms with poor IEQ, including thermal performance, are known to cause absenteeism among staff and pupils, and negatively affect the performance of children. Children are at particular risk since they are more susceptible than adults to the effects of poor air quality, which can be "subtle and do not always produce easily recognisable impacts on health and wellbeing" (Lee & Chang, 2000). Moderate heat stress can affect children's mental performance. This was suggested when a sample of young people's mental performance was significantly affected by the slight temperature increase of only a very few degrees within the range likely to be found in a typical classroom (Wyon et al. 1979).

A child inside a classroom collects the majority of information about their surroundings through their auditory and visual systems. The later is stimulated by light reflected off surrounding surfaces. The quantity of light affects the child's nervous system and neuroendocrine hormonal system (Edwards and Torcellini 2002) while the quality will profoundly affect the children psychologically and physiologically. Poor acoustic performance of classroom affects the occupants and increases the strain on the teachers' voice (Stansfeld and Haines 2002). Children in primary classrooms are particularly vulnerable to noise effects because it can interfere with the learning process during a critical developmental period. Children exposed to noise in schools showed "deficits in sustained attention, visual attention, concentration, poorer auditory discrimination and speech perception, memory impairment and poor reading ability and (decreased) school performance" (Stansfeld and Haines 2002).

2. Previous work

Previous work conducted across several countries in the area of schools' internal air quality (IAQ) found that most of the case studies were inadequately ventilated and were high energy consumers. In the UK, the Building Research Establishment (BRE) in an attempt to assess the performance of the current stock of new school buildings monitored the ventilation and indoor air quality inside a representative sample of primary schools in England (BRE 2003). Results showed that 50% of the measurements were under the minimum rate required by the British Standards. Another study looked into the recommended suitable ventilation rates for classrooms and examined the suitability of the air quality guidelines for classrooms (Clements-Croome et al. 2005). A recent comprehensive study in the UK found that the attention of children inside a poorly ventilated school was significantly slow (Clements-Croome et al. 2008). Other studies (Cook 1990; Galasiu and Veitch 2006; Stewart 1981) looked into the behaviour and attitudes of children towards the visual environment of classrooms and the effect of artificial lighting on energy consumption. They found that many primary classrooms in the UK and abroad fail to meet the minimum requirements of the illuminance and glare protection recommendations given by different lighting codes.

Studies that looked solely into the thermal performance of classrooms (Corgnati et al. 2007; Kwok and Chun 2003; Lin et al. 2005) showed that the occupants of the majority of cases were not thermally comfortable most of the time. Only few studies

(Becker et al. 2007; Gado et al. 2005; Kruger and Zannin 2004; Wong and Jan 2003) looked into a combination of more than one environmental factor.

Previous work in general is limited to cold and temperate climates. Knowledge about the environmental performance of schools in hot-dry climates is very limited. In Egypt, the majority of the researches approached school design from social, educational, economical or theoretical points of view and very few looked into their environmental design. Toulan focused on the conceptual design of primary schools (Toulan 1982). Abdalla studied the impact of new educational tools on both conceptual design and human dimensions in schools (Abdalla 1994). Others studies (El-Mola 1999; Shalabi 1996) investigated different ways of architecturally responding to the educational process. El-Nashar studied the physical setup of the educational spaces and its impact on children's behaviour (El-Nashar 1998). Noufal studied factors affecting schools built in overcrowded districts of Cairo (Noufal 1998). El-Hefnawy investigated health and safety issues in educational buildings and especially in primary and preparatory schools (El-Hefnawy 2002). The Housing Building and Urban Planning Research Centre conducted a research aiming to formulate guidelines for designing fundamental schools in Egypt (Housing Building and Urban Planning Research Centre HBURC 1987). This study looked into the quality of educational spaces, their occupants' responses and their environmental performance. The most recent research was conducted by the Institute of Environmental Studies and Research (Institute of Environmental Researches and Studies (IERS) 1992) investigating the conceptual design of schools, landscape, materiality, and solar shading but failed to investigate their environmental performance.

It is clear that only few studies have touched on the environmental performance of primary schools in Egypt. The majority of work has been oriented towards other aspects of primary school design. This gap in the body of knowledge was identified and is being approached in this research project.

3. Research background and problem

The demand for primary schools in Egypt is one of the stressing issues facing the Egyptian Government since the earthquake of 1992. This demand had considerably doubled during the last fifty years when the 1952 Revolution provided the members of all sectors of the community with free education and abolished fees for public schools. The Ministry of Education's budget was doubled in one decade and the expenditures on school construction increased by 1000% between 1952 and 1976 (Metz 1990). Providing free education to children from all social sectors dramatically increased the demand for educational infrastructure including school buildings. In the early 1990s the Egyptian Ministry of Education increased the number of primary school years from 5 to 6 and subsequently the demand increased again (Gado et al. 2005). This demand had also substantially increased after the 1992 earthquake that hit Egypt with a magnitude of 4.7 on the Richter scale (Farag 2002). The tremor affected 3964 buildings including a considerable number of schools. In response, the Egyptian Government established the General Authority of Educational Buildings (GAEB) to design new schools around the country.

GAEB uses the same prototypical designs to build schools across the different climatic design regions of Egypt without any consideration to the variation in climatic conditions (Figure 1-A).

All prototypes are designed in cellular fashion using standardized structure and construction systems on a very low budget. By the mid 1970s the "public investment in new educational infrastructure has declined in relation to total educational expenditures; about 85 percent of the Ministry of Education's budget has been designated for salaries" (Metz 1990).

Although this approach could have allowed rapid build, the new classrooms are rigid and uncomfortable. Previous work (Gado et al. 2005) suggested that the internal environmental quality of classrooms in new Governmental schools in Egypt is very low. This can prove damaging and can bread resentment for the space. The design hinders the activities occurring within, and do not respond to the changing needs of primary education imposed by the Government new reforms. Classrooms are arranged along long corridors in an age hierarchy with no common spaces or activity halls. Bad primary school design is of a great concern since children in Egypt up to the age of twelve spend from around 22% of their time in mainstream schooling, with primary schools representing 44% of all pre-university education (Ministry of Education 2005).

4. Research Methodology

This work aims to investigate the environmental performance of governmental primary schools in Egypt. In this part of the paper, the subjective assessment of nineteen case studies representing the three most common prototypes used by GAEB in al-Minya and represent 80% of the primary schools built across the country (GAEB 2004). Al-Minya Governorate lies in the desert climatic design region; the largest region in Egypt (Figure 1-A). The case studies included 5 schools of the six classrooms prototype (T6) single-loaded and double-loaded, 9 schools of the twelve classroom prototype (T12) single-loaded, double-loaded and L-shape plans and 5 schools of the eighteen classrooms prototype (T18) double-loaded. The case studies are located in seven different towns of al-Minya Governorate, twelve were built in rural context and seven were built in urban context (Figure 1-B).

The field study was conducted on three stages. The first stage collected information about the environmental performance of 18 case studies. Ten factors indicating the environmental performance of school buildings were observed across the case studies. These were: the water use, energy consumption, land use, health and safety, environmental impact of materials, internal air quality, thermal performance, visual performance, noise control, space acoustics. Analysis of results indicates that all schools performed very poorly across all investigated factors. However, thermal, visual and acoustic comforts inside classrooms were found to be the major problems (Gado et al. 2005).

In the second stage, the subjective response of 108 occupants (29% were females) inside 54 classrooms were gathered during May 2005; the hottest month of the year in al-Minya during the academic session (mid September to early June). Six occupants were chosen randomly from each school, three pupils and three teachers. Observation and semi-structured interviews with closed ended and open ended questions had been employed to investigate the thermal, visual and acoustic comfort inside the classrooms. The interviews were used to collect data related to the occupants' state of comfort inside the classrooms. Interviews used open ended questions to explore the subjective response of the occupants, while closed ended questions were used to allow the application of statistical analysis on the results. Analysis of results suggested that the thermal comfort is the most critical issue across the case studies. (Gado et al. 2005).

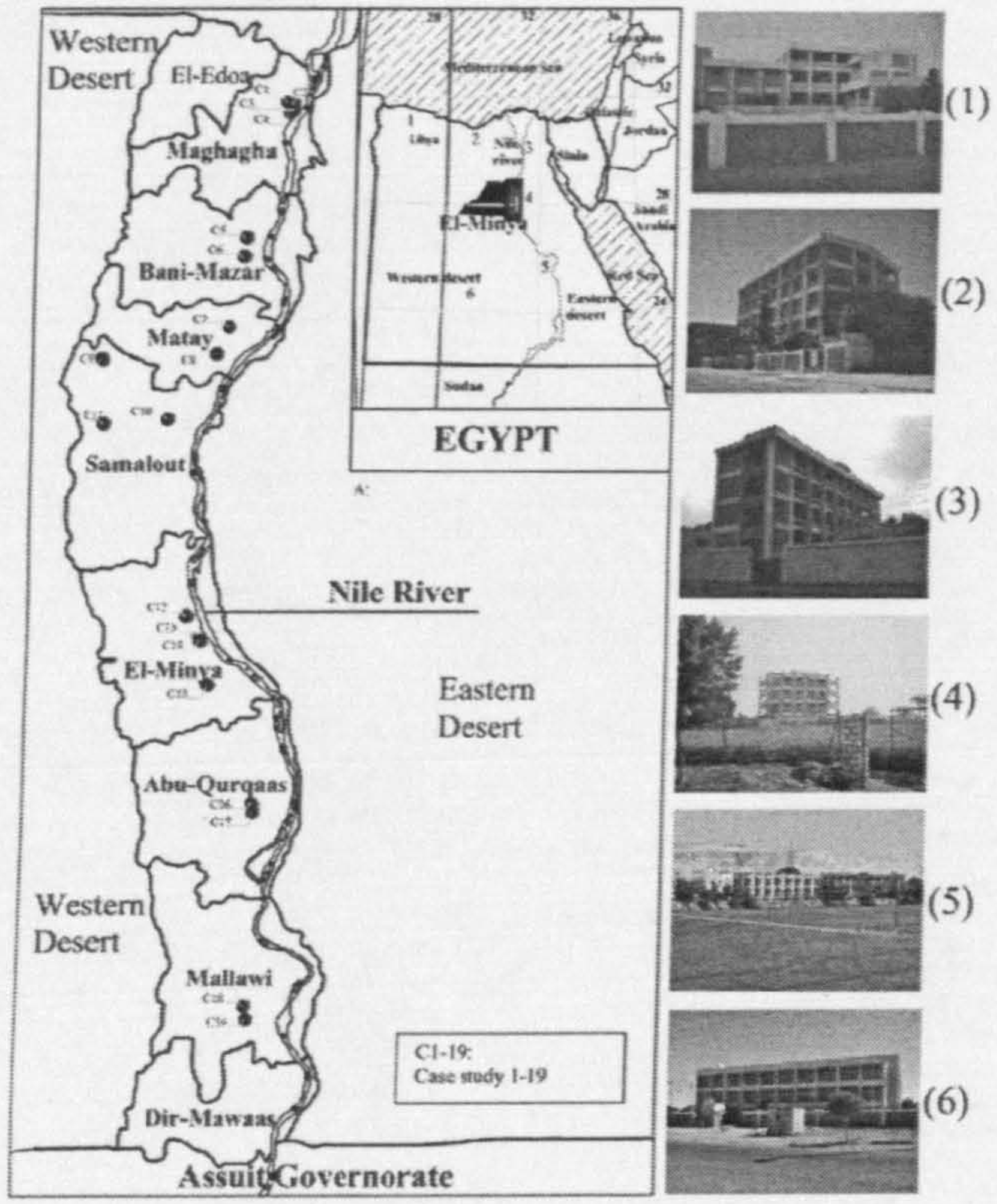

Figure 1: A: Examples of prototypical schools in different climatic zones / **B:** Location of the case studies in al-Minya Governorate

In the third stage, the thermal comfort inside five classrooms of three schools was investigated in details. Two schools were chosen from the 18 cases previously studied and an additional school was employed. The three schools were; Omar ebn al-Khatab primary school (leaner single-loaded), al-Lamaty primary school (leaner double-loaded) and al-Shaheed primary school (L-shape) (Figure 2 -
Figure 4) These schools represent the three prototypes commonly built in al-Minya.

Figure 2: Omar ebn al-Khatab primary school

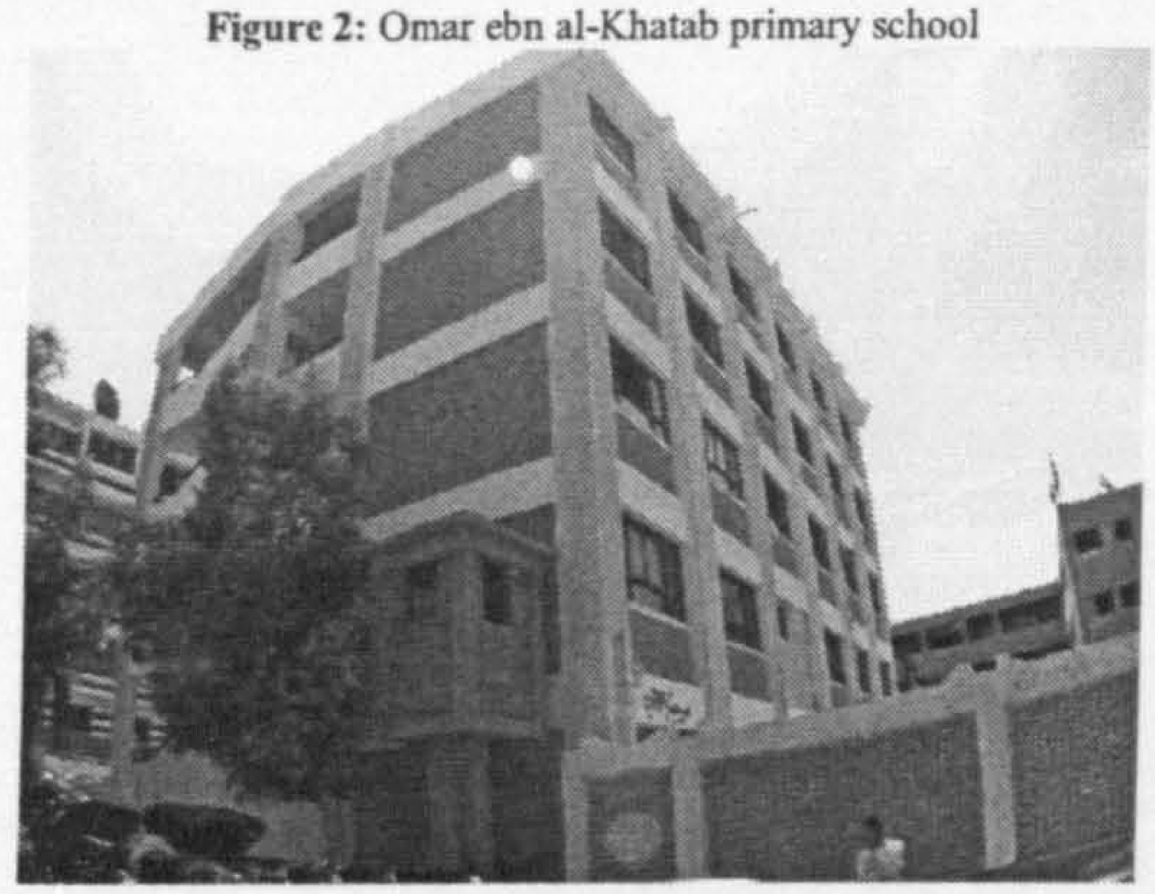

Figure 3: Al-Lamaty primary school

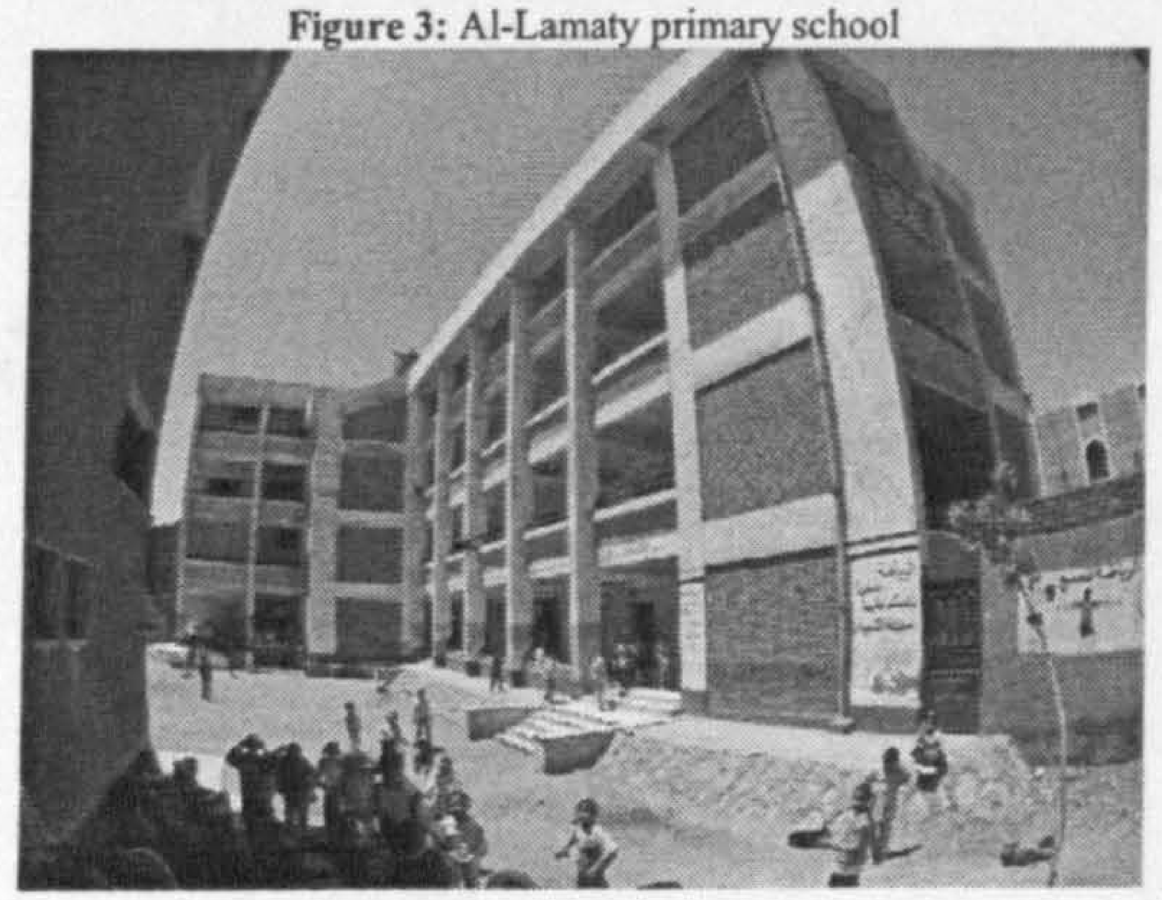

Figure 4: Al-Shaheed primary school

Multi-approached techniques were employed to collect data from 168 occupants (87% were pupils and 43% were female) inside the 5 classrooms during May 2007. Semi-structured interviews and questionnaires were employed. The questionnaire was used to collect data from occupants inside several classrooms at the same time. This allowed the comparison of data collected from different spaces within the same school but have for example different solar and wind orientations. However, since not all young children are capable of using conventional thermal comfort rating-scales (Humphreys 1977), interviews were used with children under 9 years old. Interviews included 24 closed ended questions and 7 open ended questions. Questionnaires included 24 closed ended questions. All the questions were related to the sensation of thermal comfort inside the classrooms. ASHRAE seven point scale (ISO 1998) was used to allow the interviewee to rate their perception of the thermal environment. Any difficult expression such as 'thermal comfort, slightly warm…etc' were explained to the subjects prior to the interviews or the questionnaires.

5. Results and discussion

Analysis of data collected from the first and second stages suggested that the majority of occupants were in discomfort for most of the academic year. 78% of the occupants were thermally uncomfortable, 58% were visually uncomfortable and 21% reported that the acoustics of the classrooms were poor (Figure 5).

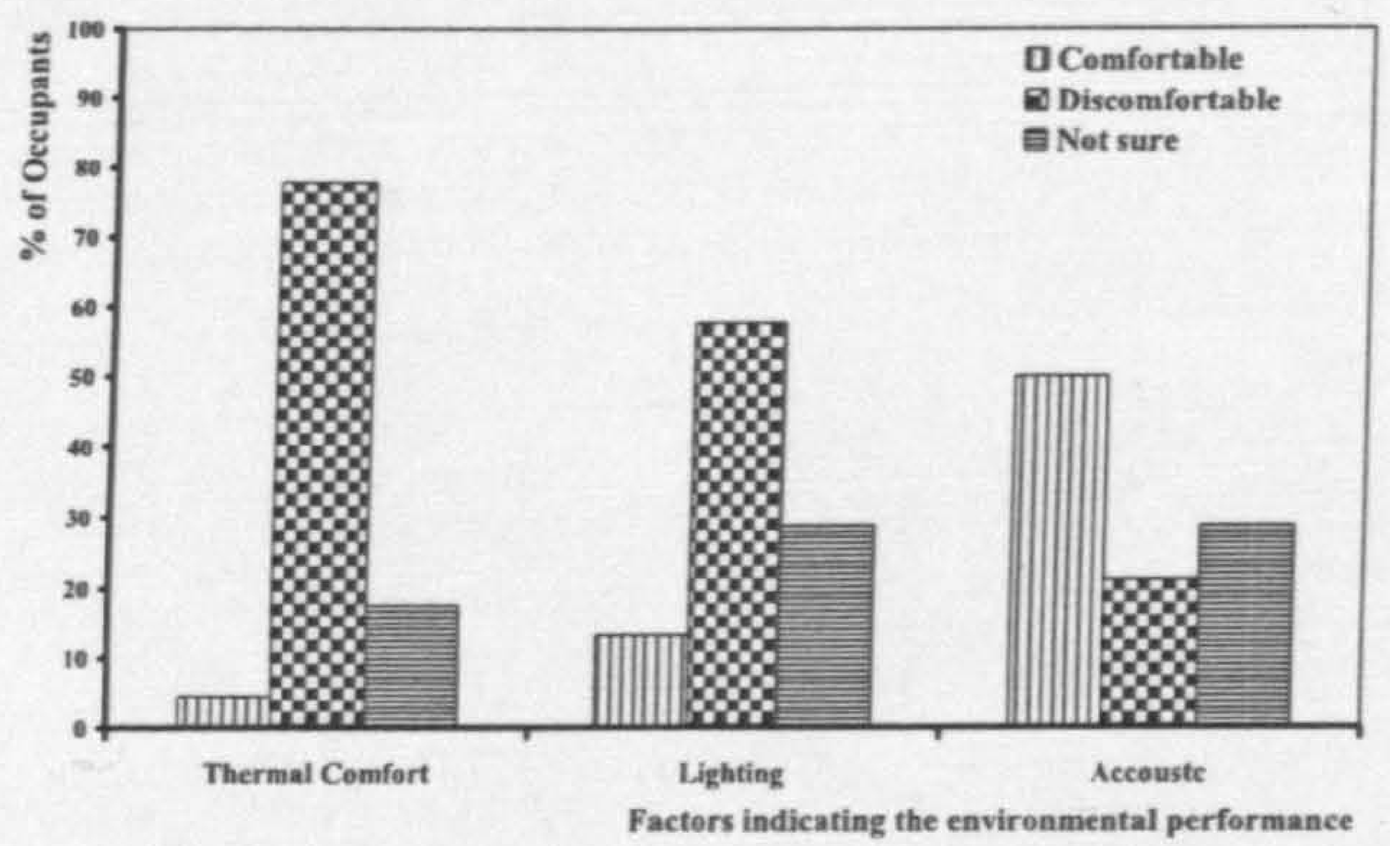

Figure 5: Percentages of occupants reporting discomfortable, comfortable or not sure

Analysis of data collected from stage three indicated that 86% of the occupants were thermally uncomfortable with only 14% reporting to be neutral. 34% of the uncomfortable subjects were hot, 18% were warm, 33% were slightly warm (Figure 6).

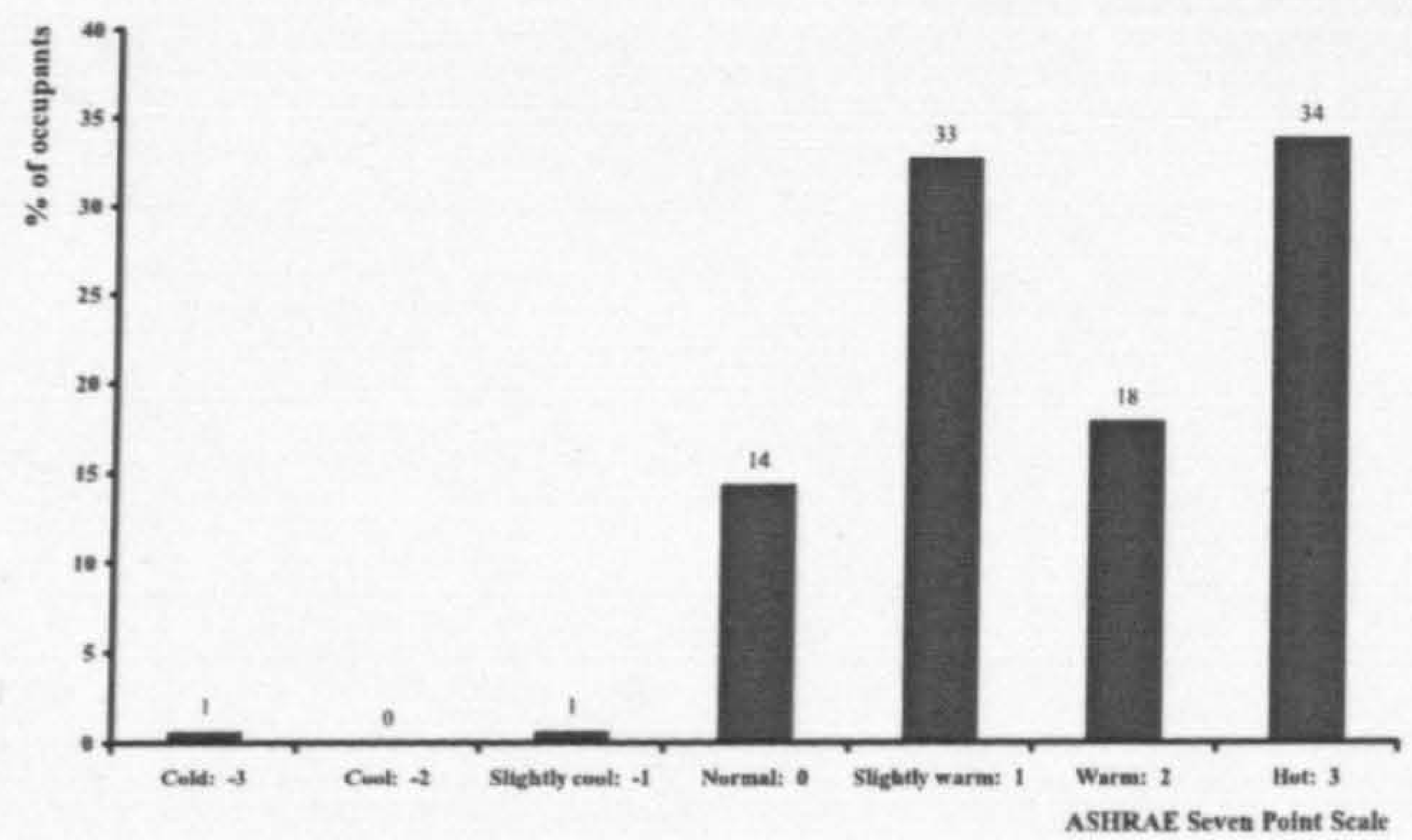

Figure 6: Percentage of occupants' response at each point on ASHRAE Seven Point Scale

Predicted Percentage Dissatisfied (PPD) was calculated using the data collected and was found to be 53%. This suggests that the majority of the occupants inside the case studies are thermally uncomfortable during the overheated period of the academic year. Observations and analysis of the case studies suggest that this could be due to several reasons:

- High occupancy density reaching 0.8 m^2/person in comparison to the average density in British classrooms that ranges from 1.8 to 2.4 m^2/person;
- The building envelope has a very low insulation capacity that ranges between 2.8 and 5.1 $W/m^2.K$ with all external walls and roofs not thermally insulated;
- The high solar heat gain coefficient (SHGC) caused by the relative high window to wall ratio reaching 32% plus high incident solar radiation on windows (ex: incident solar radiation typically ranges between 327 and 900 w/m^2 on the 24th April at 2.00 pm);
- Inadequate solar orientation causing high solar gain through windows. This plus the high outdoor air temperature pushes the conditions inside the classroom outside the thermal comfort zone;
- High shading coefficient (SC) values due to the use of large un-shaded areas (8 m^2) of glazing. This caused almost 25% of the pupils occupying the classroom to be hit by direct solar radiation for prolonged periods of time during the overheated month. This beside the high indoor air temperatures reaching $36^{\circ C}$ can lead to thermal discomfort and can cause sunstroke in severe cases;
- Windows are single glazed and poorly constructed with very high levels of air permeability. This caused high levels of heat gain through ventilation during overheated periods and cold draughts during under heated periods;
- The design of windows does not allow natural ventilation;
- In some cases children and teachers had to paint the windows in dark colour or stick newspapers to avoid discomfort and disability glare caused by the direct solar radiation. (Figure 7). This consequently led to a severe drop in the levels of natural light and the use of artificial

lighting during daylight hours consuming unnecessary energy. In most cases the informants confirmed that they can not open the windows any way to induce natural ventilation because of the high levels of air and sound pollution outside the schools. This lead to very low internal air speeds reaching less than 0.1 m/s with no simple mechanical ventilation provided. This also led to low levels of air change and consequently caused the classrooms to be stuffy and smelly;

Figure 7: Windows covered and painted by the occupants after Gado and Mohamed (Gado et al. 2005)

- In very few cases, when the occupancy density is low, children move places to avoid direct solar radiation disturbing by such the educational process. This does not solve the problem any way since overcrowding at shaded areas contributes to the children's thermal discomfort (
- Figure 8).

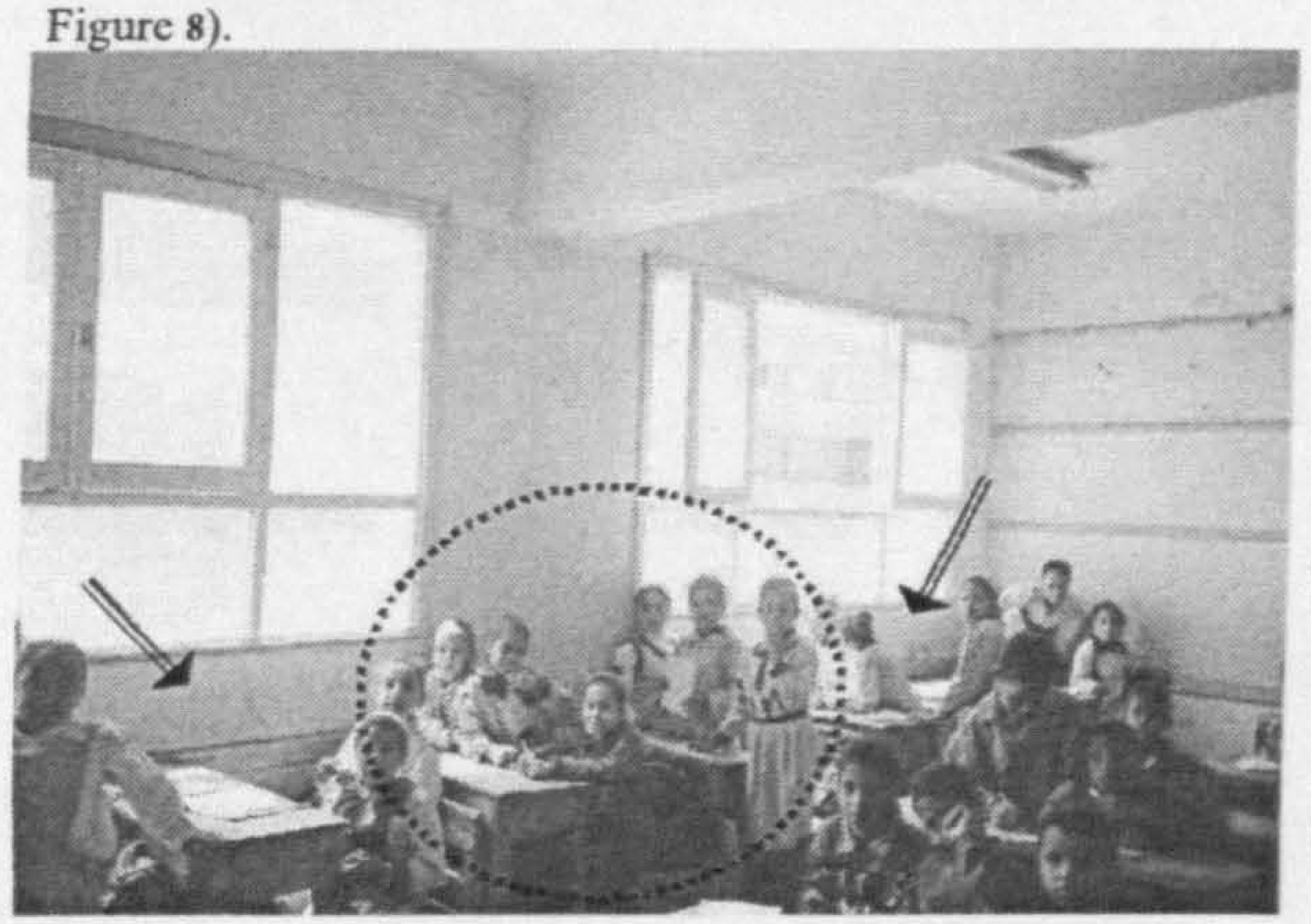

Figure 8: Directed solar radiation falling on the children, after Gado et. al. (Gado et al. 2005)
Sunny areas Shaded areas

6. Conclusions and further work

This research was concerned with the subjective assessment of thermal comfort inside governmental primary schools in Egypt as a representative context of hot dry climate. Semi-structured interviews and questionnaires were employed and 276 subjects were used. The results suggested that the majority of the occupants are thermally uncomfortable in most of the cases during most of the time.

Work is conducted to objectively assess the thermal performance of the classrooms and to further investigate the causes of the problem. Results of this work are presented in the second part of the paper.

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8. Acknowledgment

The authors would like to thank the Egyptian Ministry of Higher Education for the full PhD scholarship granted to the second author Mady Mohamed. The later is an assistant lecture on a sabbatical leave funded by Zagazig University. Mr. Mohamed would like to thank the Zagazig University and the Egyptian Government for their financial support and the Egyptian Education and Culture Bureau in London for their effort in managing his scholarship. He would also like to thank Dundee School of Architecture for the continued support. Thanks are also due to Mr. Don Alexander of the Welsh School of Architecture for providing the authors with HTB2.

Paper 4:
Assessment of thermal comfort inside primary governmental classrooms in hot-dry climates Part II – A case study from Egypt

SUEMoT

SUE-MoT Conference 2009

Second International Conference on Whole Life Urban Sustainability and its Assessment

Loughborough, UK *22-24 April 2009*

Conference Proceedings

Editors: M. Horner, A. Price, J. Bebbington, R. Emmanuel

First published in Great Britain in 2009 by Loughborough University

Typeset in Warnock Pro using Adobe InDesign, XeLaTeX and PDF::Reuse by James Sutherland, University of Dundee

All papers were double-blind reviewed.

ISBN-13 978 0 947974 81 7

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Assessment of thermal comfort inside primary governmental classrooms in hot-dry climates Part II – a case study from Egypt

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Previous work (Gado and Mohamed, 2009) investigated the subjective response of occupants inside nineteen primary schools in Egypt with regard to their state of thermal comfort. The results of this work, suggested that the majority of occupants were thermally discomfort for most of the time during the academic year. This paper presents an objective assessment of the thermal comfort inside three case studies out of the nineteen schools previously studied. These three case studies represent the most common school prototypes built by the General Authority of Educational Buildings (GAEB) in Egypt. The three prototypes are: Single Row Linear Form (SRLF), Double Row Linear Form (DRLF), and L Form (LF). Human and environmental factors affecting thermal comfort were monitored during the hottest month of the academic year. Results suggested that thermal performance of classrooms in terms of thermal comfort was poor, justifying by such the results of the subjective assessment previously published.

Keywords: assessment, assessment tools, environmental assessment, performance, sustainable buildings

1. Introduction

In the first part of this paper, thermal comfort inside nineteen case studies was subjectively assessed. Analysis of results suggested that the occupants were thermally discomfort most of the time during the academic year. This part of the paper presents the findings of a study where thermal comfort inside three case studies out of the nineteen schools was assessed objectively.

2. Research background

It is relatively difficult to access thermal comfort inside buildings due to the complexity of the contributing factors deciding whether the conditions in question will make people feel discomfort or not. It is generally agreed that factors affecting thermal comfort inside buildings can be grouped into two groups; human factors and environmental factors. The later include air temperatures, air velocity, mean radiant temperature and relative humidity while the human factors include insulating value of clothing (Clo) and the metabolic rate (Met) that depends on the activity level. Szokolay added a third category and called it the contributing factors that include the person's age, gender, food, drink, body shape, subcutaneous fat, colour of internal surfaces and lighting system used (Szokolay 2004). Fanger and Humphreys (Humphreys 1977) in addition to several studies cited in ((CIBSE 1999), pages 1-10) revealed that, at a given activity and clothing level those contributing factors do not significantly affect thermal comfort.

From all the environmental factors, air temperature is the most commonly used indicator of thermal comfort (Rosenlund 2000) and is considered to be the most important factor determining heat stress. Mean radiant temperature which is determined by the temperature of the surrounding surfaces is also a significant factor contributing to thermal comfort. Relative humidity is another important factor affecting thermal comfort. High levels of humidity inside buildings prevent the evaporation of sweat from skin; the main method human body losses heat (Givoni 1976). In hot climates this could have a significant effect on the thermal comfort. On the contrary, low humidity levels can cause symptoms such as dryness of throat and skin, and can cause irritation of the mucous membranes. In normal circumstances, relative humidity should range from 40 to 70% (CIBSE 1999). Another factor affecting thermal comfort is air movement which is not to be confused with air change and is not always caused by ventilation (McMullan 2002). It affects the evaporative capacity of the air and consequently the cooling efficiency of sweating (Givoni 1976). Air movement helps the heat loss from human body by convection, but it can in some cases cause the sensation of draught (McMullan 2002). A related factor to air movement is the ventilation rate. Results from previous research (Ajiboye et al. 2006; Clements-Croome et al. 2005; Coley and Beisteiner 2002; Griffiths and Eftekhari 2008) suggested that children studying in ill ventilated classrooms are likely to be less attentive. The concentration of carbon dioxide (as an indication of ventilation rate) in all teaching and learning spaces at seated head height should not exceed 1500 ppm (Department for Education and Skills 2005). The minimum required ventilation rate in any teaching area is 3 l/s per person. It is recommended that the ventilation approach used in school buildings should be capable of providing an enhanced rate of at least 8 l/s per person to be able to handle sudden increase in ventilation needs (Kukadia et al. 2005).

3. Monitoring methodology

Five classrooms inside three case studies from the previously investigated nineteen schools(Gado and Mohamed In review) were chosen. The layout and typical plans of the schools are presented in Figure 1- Figure 3. The environmental factors affecting thermal comfort (air temperature, relative humidity, mean radiant temperature, and ventilation rate) were monitored during the same time of the subjective assessment. This took place during the hottest months of the academic year; May. This allowed the comparison between the subjective response of occupants and the objective assessment of the environments.

Figure 1: Case study 1 layout
Notes: a) classroom under investigation is hatched
b) Numbers on surrounding buildings are their height in meters

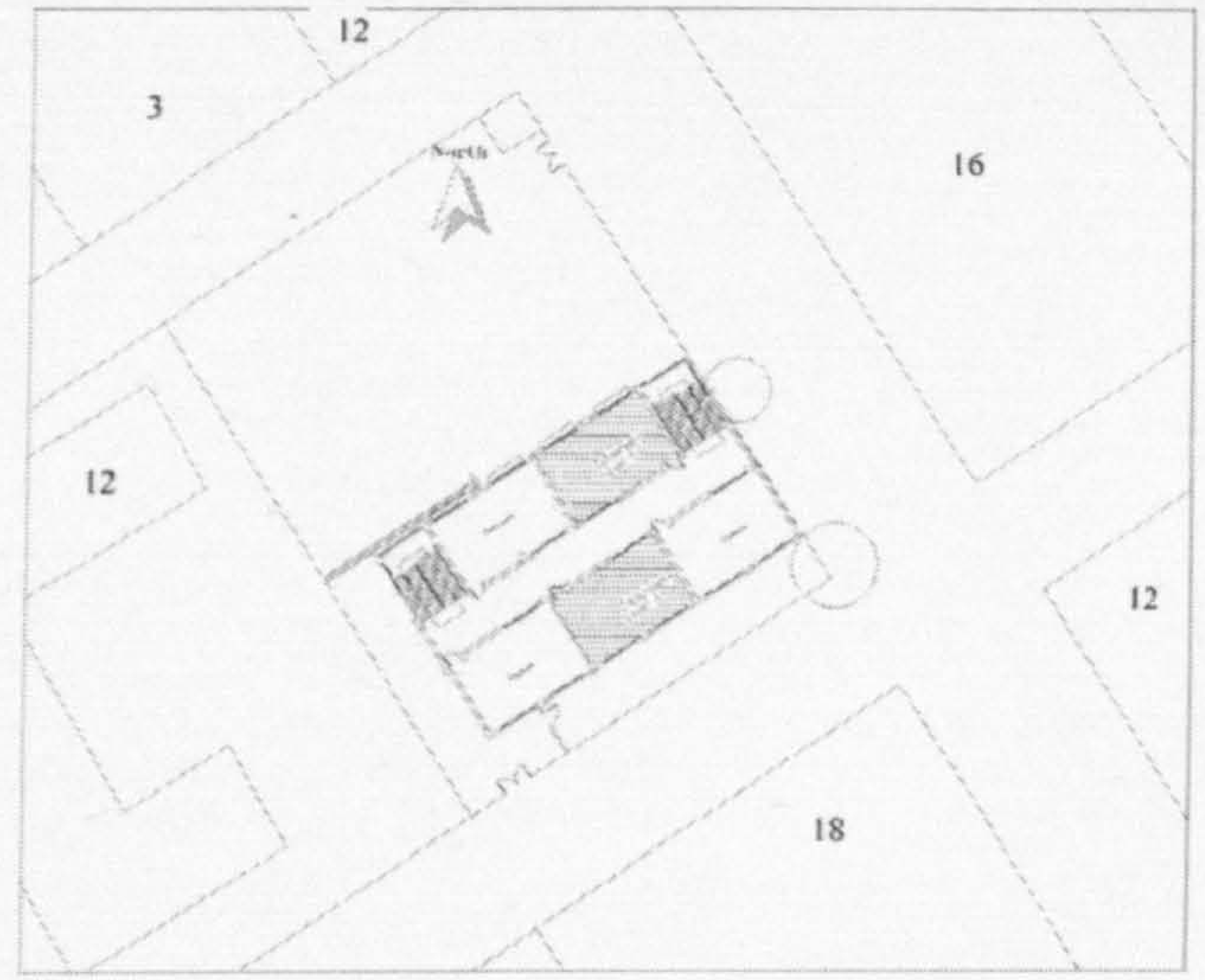

Figure 2: Case study 2 layout
Notes: a) classrooms under investigation are hatched
b) Numbers on surrounding buildings are their height in meters

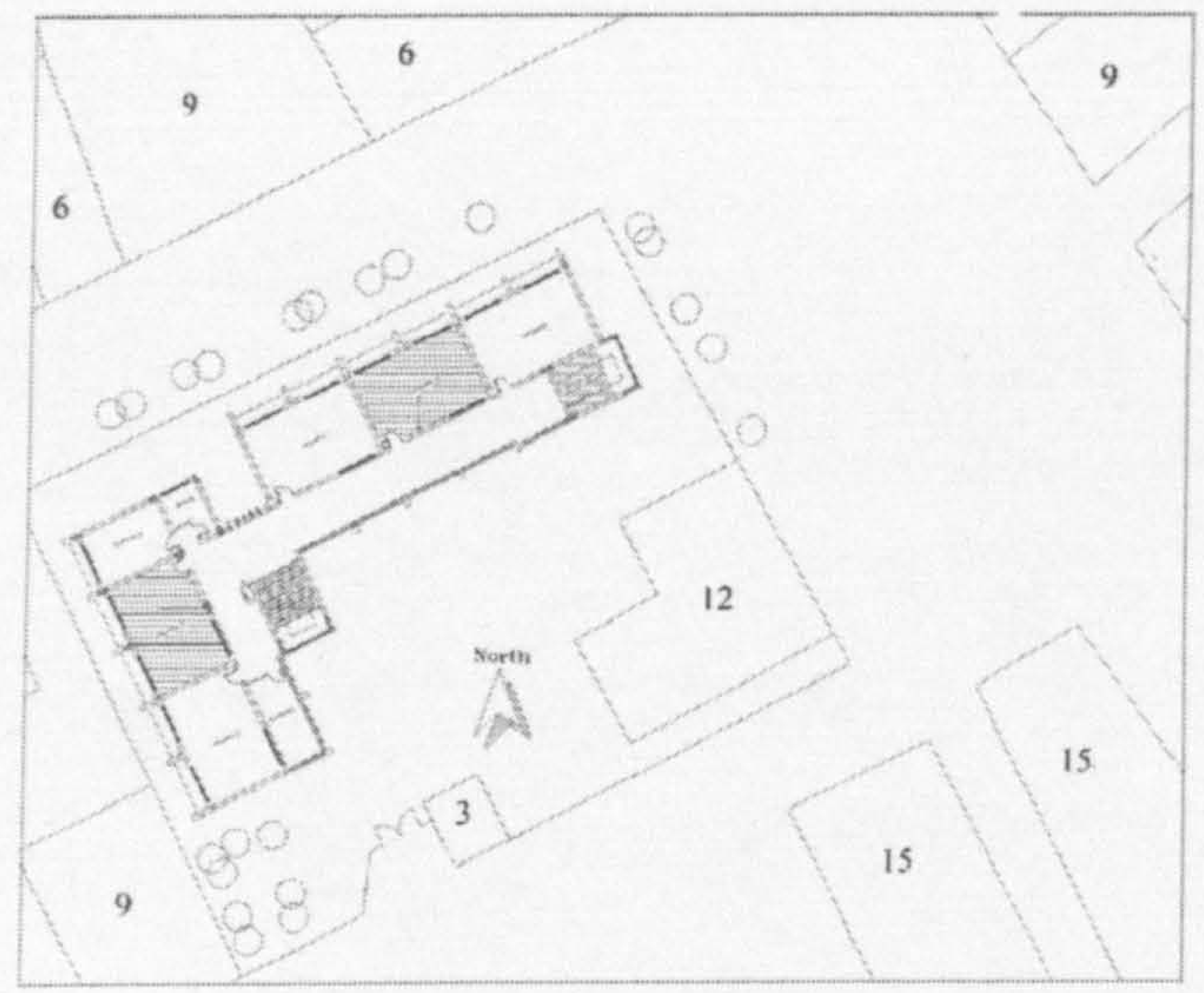

Figure 3: Case study 3 layout
Notes: a) classroom under investigation is hatched
b) Numbers on surrounding buildings are their height in meters

Due to the young age of occupants, it was important to choose a reliable data logger that could be easily concealed away from the children and can be quickly installed while accurately logging and storing data for the duration of the investigation. For this Hobo U12 was chosen to log air temperature and relative humidity. Two external sensors (TMC6-HD) were connected to the logger to allow taking measurements at three levels as shown in

Figure **4** and

Figure **5**) a) ankle level (200 mm above floor level) b) head height (1100 mm above the floor, the standard height according to ISO 7726:1998 (ISO 1998) c) below the ceiling height by 200 mm (Figures 4-5).

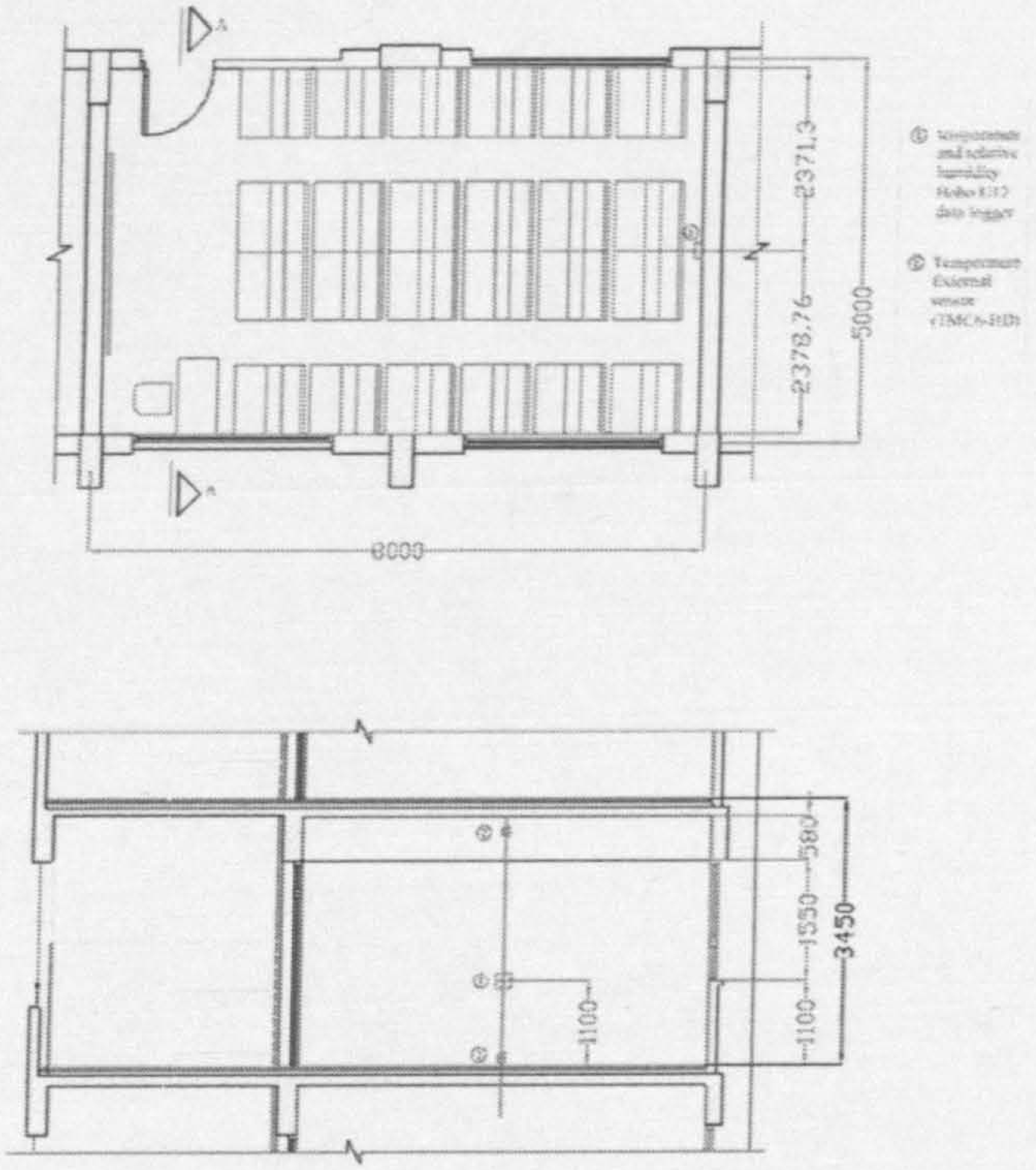

Figure 4: Location of the Hobo U 12 data logger and sensors inside the classroom

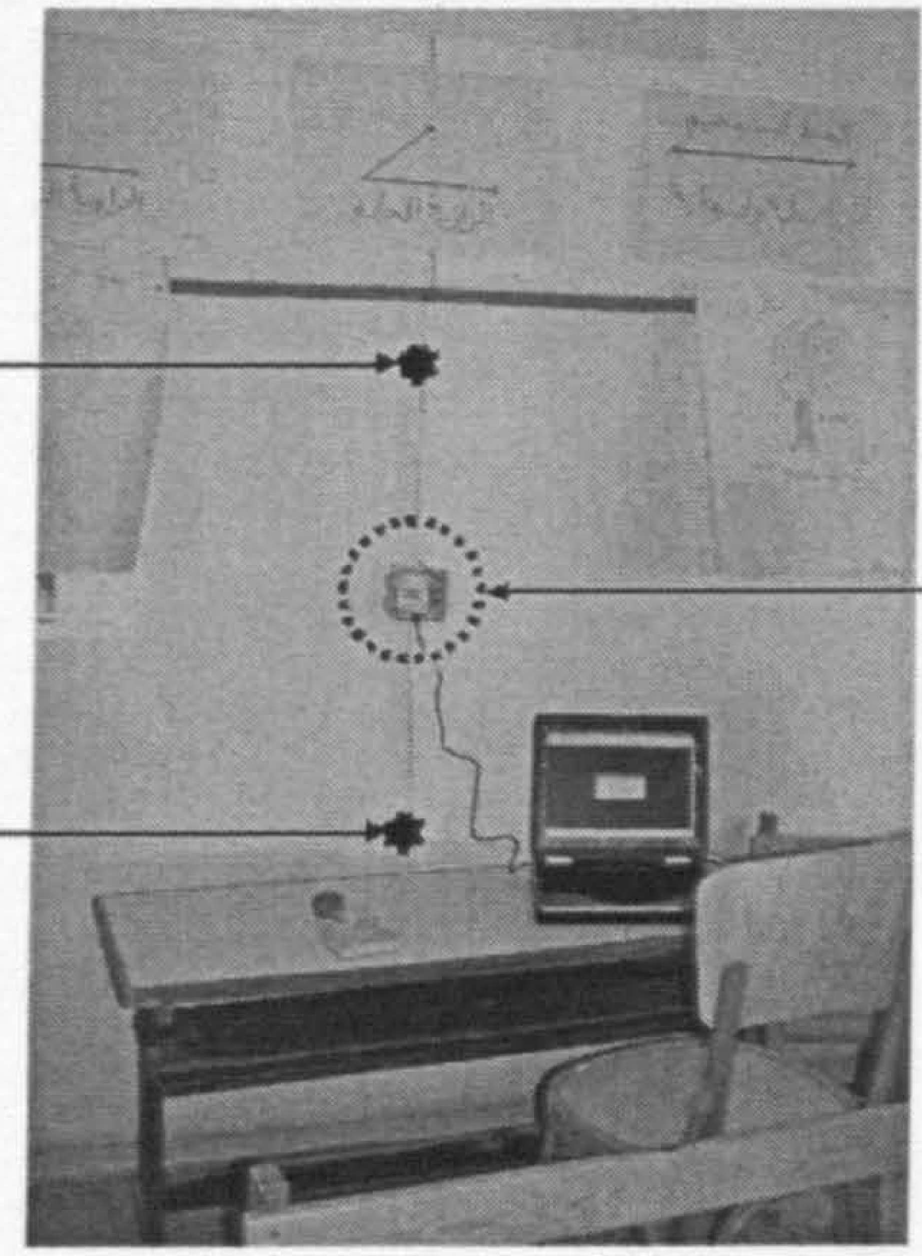

Figure 5: Hobo U12 and sensors on the back wall of the classroom

Measuring the temperature at those levels allowed studying the temperature stratification inside the classroom; a factor affecting thermal comfort. The effect of temperature stratification is important since a large difference between head and ankles temperature can cause discomfort (ISO 1998). Ideally, the feet should be a few degrees warmer than the head (Environmental Engineering Science 2007) and this should not exceed 3∘C (CIBSE 1999). Studying this factor will also generate data to allow further work to investigate the application of passive ventilation systems.

Internal air speeds were measured at several points over a period of a day using a hand held anemometer. Ventilation rate was gauged by logging the CO2 concentration levels every two seconds over a single day using a TEL-7001 Telaire CO2 Monitor H22-001 sensor and a Hobo FlexSamrt data logger. CO2 levels was used as an indication of the indoor air quality and ventilation rates inside the classrooms (ASHARE and American Society of Heating 1999). In this case, it was not possible to log the CO2 inside the classrooms over the whole month as it was not possible to leave the monitoring equipment unattended.

Mean radiant temperature were calculated using the surrounding surfaces temperatures at seated head level at the centre of the classroom using equation 1 (ASHRAE 2005) and the angle factor between the location and the measured surfaces was determined graphically using ASHRAE hand book method (ASHRAE 2005).

$$tr = t_1{}^4 Fp\_1 + t_2{}^4 Fp\_2 + \ldots\ldots + t_n{}^4 Fp\_n \quad \text{.........equaiton 1}$$

Where

Tr= mean radiant temperature

TN^4 = surface temperature of surface N

Fp_N = angle factor between a person and surface N

An infrared thermometer (MicroRay Pro++) was used to measure the temperatures of all the internal surfaces of the classroom. The equipment used is a high-end thermometer that features adjustable emissivity allowing the measurement of the temperature of any surface irrespective of its material.
Outdoor climatic conditions were logged over the same period using Hobo microstation (H21-002). Measurements included air temperature, relative humidity, and direct solar radiation. This data were then compiled and a meteorological data file for Al-Minya was created.

4. Results and discussion

Clothing level affects heat exchange between the body and the surrounding environment by forming a barrier to the convective and radiative heat exchange between the body and the environment (Givoni 1976). Different cloths will have different effects on the required comfort temperature. It was found during the field study that children's ability inside the classrooms to adapt their clothing level by adding or removing layers of clothing according to their thermal environment was very limited. The boys' typical uniform at the time of the survey was a long sleeve shirt or tee-shirt and a long trousers, socks and shoes. Girls' typical uniform was a dress with long trousers, socks and shoes. In some cases their clothes were similar to the boys' uniform. Normal underwear was assumed to avoid offence. In all cases it was found that the clothing was equivalent to a value of 0.7clo (ISO 1998).
Level of activity affects the metabolic rate which in turn affects the body temperature. Under the current Egyptian education system, children inside primary classrooms are seated in pairs on a 900mm wide wooden desk for long periods of time. This level of activity metabolic rate is equivalent to 70w/m2. The average total number of children per classroom under investigation was 48 i.e. 0.83 m2/pupil. This high density is expected to contribute to the level of thermal discomfort. The classroom furniture is arranged in three rows perpendicular to the blackboard as seen in
Figure **4**. Children in this setup are normally not allowed to change there location during the lessons. This means that almost 25% to 35% of the children are left in direct solar radiation (Figure 6) across the academic year depending on the time of the day and the solar orientation.

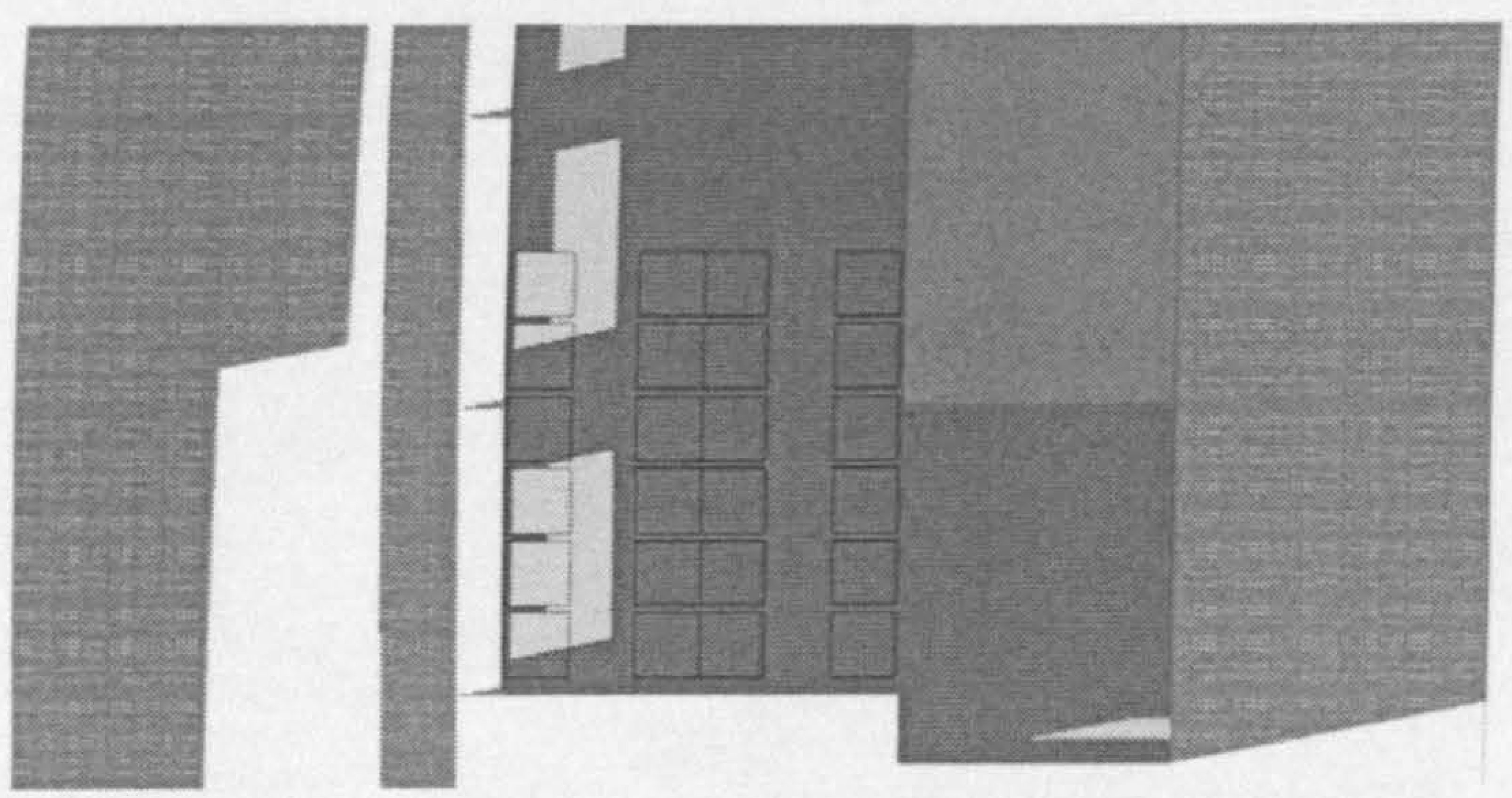

Figure 6: Solar penetration at 14:00 during mid May

All the classrooms under investigation were naturally ventilated. However, there were several reasons that prevented the effective use of windows. They were closed most of the time and in many cases were painted in black or covered with newspaper to prevent solar penetration. This consequently led to a severe drop in air speeds, which were less than 0.1 m/s across the five cases. Even when all the windows were opened, air speeds were not noticeable inside the classroom and slightly exceed 0.1 m/s only near the windows.

CO2 levels in two of the five classrooms exceeded the recommended levels of 1500ppm (Department for Education and Skills 2005) reaching 2142ppm and 1908ppm respectively. In is worth mentioning that there were no measures in place that could respond to sudden ventilation needs.

The average internal air temperature across the case studies was 29˚C. It exceeded 30˚C for 23% to 48% of the time, reaching just over 34˚C in some cases. Over a single day the internal temperature varied by more than 2˚C during 58% of the time across the case studies. According to Humphreys (Humphreys 1977) this level of variation in internal air temperature could result in incident of discomfort. Humphreys suggested this might be due to that fact that children are sent to the schools wearing relatively warm cloths in the cool morning than required for the range of temperature during the day. In the context of this work, this could only be true during winter when morning temperatures are relatively low ranging from 06˚C to 119˚C at 8am. Air temperature at head level was always higher than the temperature at the feet level by an average of 0.5˚C reaching in some cases a difference of over than 2˚C for 20% of the time increasing by such the state of thermal discomfort.

Levels of internal relative humidity ranged from 17.8% to 52.6 % during the operation hours. For 80% to 96.4% of the time, relative humidity was under 40% across the case studies and was less than 30% for 5% to 41% of the time. This low level of humidity may be acceptable for short periods as long as there are precautions to limit the generation of dust and airborne irritants (CIBSE 1999). In this case, there were no precautions taken to limit this from occurring and in turn this increased the discomfort of occupants as suggested by the subjective assessment.
The year during which this work was conducted was slightly hotter than the typical meteorological year. Typically the average outdoor air temperature in Al-Minya during the school operation hours (8am - 1pm) is 26˚C, reaching a maximum of 40.5˚C. However, in this case the average outdoor air temperature was 31.4˚C reaching a maximum of 43˚C. Typical average direct solar radiation is 630w/m2 when the typical value is 525w/m2.

5. Assessment of thermal comfort

In this study, two methods were employed to assess the thermal comfort inside the case studies: 1) comparing the internal temperatures with the comfort temperature 2) calculating the PMV and PPD values for the classrooms.
Using the adaptive thermal comfort model, the monthly comfort temperature and the total number of hours spent above this limit during the operation hours of the day was calculated. Figure 7 presents the internal air temperatures across the five case studies in relation to the comfort limit. Analysis of results suggested that the internal air temperature across the classrooms exceeded the comfort limit for 82.26% of the time and exceeded it by 2˚C for 43.55% of the time (Figure 7).

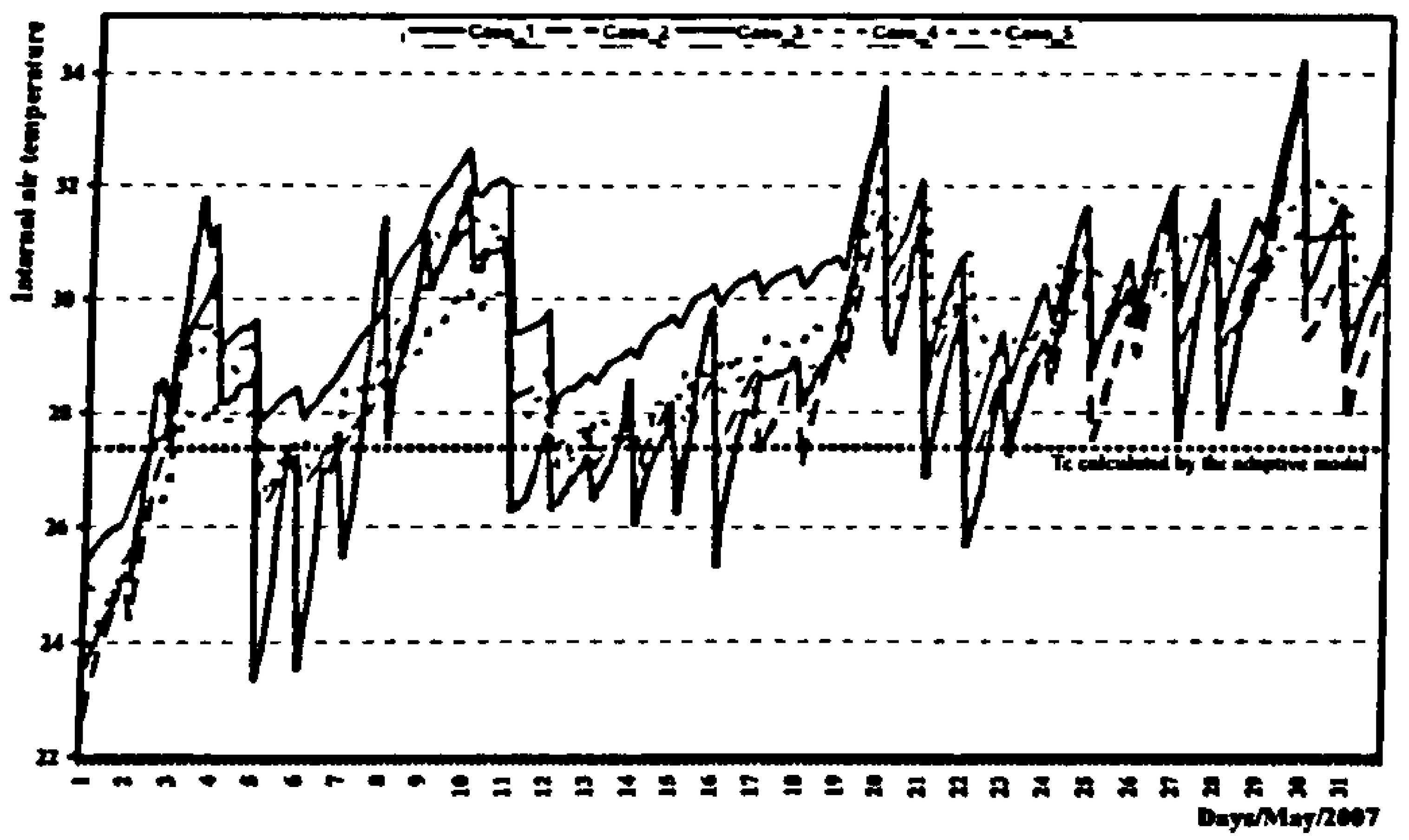

Figure 7: Internal air temperatures across the five case studies in relation to the thermal comfort temperature

The two indices widely used to predict the state of thermal comfort of occupants inside buildings are the Predicted Mean Vote (PMV) and the Predicted Percentage Discomfort people (PPD). Both the PMV and the PPD of each classroom were calculated during the operation hours (08.00 am to 01.00 pm). The average PMV and PPD across the classrooms was 1.7 and 51% respectively indicating by such a high level of thermal discomfort. The later confirms the PPD found in previous work (Gado and Mohamed In review) that was equal to 53%.

6. Conclusions

This paper was concerned with the objective assessment of thermal comfort inside three primary schools built in the desert climatic design region of Egypt. All factors affecting thermal comfort were monitored and analysed. The adaptive thermal algorithm was used to calculate the comfort temperature and both the PMV and PPD indices were calculated. The conclusions from the analysis of results can by summarised as follows:

1. The internal air temperatures of all the case studies exceeded the comfort temperature for most of the time;
2. Half the occupants were thermally discomfort. This was indicated by the average PPD that reached 51%;
3. Temperature difference between the head and the ankle level exceeded 2 degrees for 20% of the time;
4. Average PMV across the case studies was 1.7 suggesting that the majority of the occupants would feel warm.

7. Further work

Further work will investigate ways of enhancing the environmental performance of the prototypes used by the Government in Egypt. A computer based study is under way to quantify the effectiveness of a number of passive measures and strategies used to enhance the performance of the typical designs investigated in the paper. Further work will also investigate the effect of the climatic variation across the Egyptian climatic design regions on the thermal performance of the Governmental prototypes.

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9. Acknowledgment

The authors would like to thank the Egyptian Ministry of Higher Education for the full PhD scholarship granted to the second author Mady Mohamed. The later is an assistant lecture on a sabbatical leave funded by Zagazig University. Mr. Mohamed would like to thank the Zagazig University and the Egyptian Government for their financial support and the Egyptian Education and Culture Bureau in London for their effort in managing his scholarship. He would also like to thank Dundee School of Architecture for the continued support. Thanks are also due to Mr. Don Alexander of the Welsh School of Architecture for providing the authors with HTB2.

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Paper 5:
Investigating the process of exporting Autodesk Ecotect models to detailed thermal simulation software

Investigating the Process of Exporting Autodesk Ecotect Models to Detailed Thermal Simulation Software

Received 2 June 2008

Running head: Thermal Simulation Software

Abstract: Autodesk Ecotect[1] is a whole building simulation software that can predict the thermal, visual and acoustic performance of buildings. It is very user-friendly software that could potentially integrate with the architectural design process. Thermal performance analysis in Autodesk Ecotect is based on the Chartered Institution of Building Services Engineers (CIBSE) admittance method and thus inherits its limitations. Hence, the need to use more detailed thermal simulation tools during the final stage of a building design or research project. This paper investigated the potential of using detailed thermal simulation software (HTB2) in conjunction with Autodesk Ecotect. Five primary classrooms built in a hot-dry climatic region were monitored during 2007. The same classrooms were modelled in Autodesk Ecotect using several modelling techniques and the internal temperatures were simulated using HTB2. Analysis of results suggested that a number of necessary measures are required to ensure the reliability and accuracy of the simulation results.

Keywords: Thermal simulation, Autodesk Ecotect models, Primary schools, Hot-dry climate, Building thermal performance, Computer modelling

[1] At the time of writing up this paper, Ecotect was own by Sqaure One Research Ltd. Late June 2008, Autodesk had aquired Ecotect and the later is now known as Autodesk Ecotect <http://usa.autodesk.com/adsk/servlet/index?id=11778740&siteID=123112>.

1. Research background and previous work

Computer modelling can allow architecture practitioners, researchers and students to predict the energy efficiency and environmental behaviour of buildings. At the moment there is a wide range of detailed thermal simulation software available. A survey by Rittelmann and Ahmed (Rittelmann and Ahmed 1985) found 215 tools among the International Energy Agency (IEA) countries. According to Judkoff & Neymark (Judkoff & Neymark, 1995) there is little quality control of this software and little information is available to guide the selection of the appropriate tool for a specific case. They also found that previous work showed large unexplained predictive differences between these tools..The interfaces of widely used packages such as HTB2, DEROB-LTH, DOE-2, EnergyPlus and ESP-r in comparison to more architecturally oriented software such as Sketchup, AutoCAD or 3DMax are complicated. This is evident from the menu design, the navigation between the model input and the results. This in addition to other reasons had made it difficult to learn those tools and meant they need substantial time to master. This deters their use in architecture practice and education and limits their integration within the architectural design process. It is also relatively difficult to input building geometry to these software tools as well as to interpolate the simulation results. The model has to be introduced in some cases in textual format. This - some times - leads to inaccuracy due to human error during data input, consumes time and requires advanced knowledge of computer programming. This also does not fit with the mode of thinking in architectural practice and education.

More architects need to quickly and easily check the environmental impact of their designs in order to reduce carbon dioxide emissions and conserve energy and to comply with legislation. Whole building simulation 3D based programmes such as IES, Autodesk Ecotect can allow the three dimensional visualization of the unseen environmental attributes of architectural spaces. This can facilitate more effective understanding of the issues involved in the quantification of the environmental performance of buildings. Geometric data are introduced to those tools either from CAD programs or directly using their 3D-based interfaces. Flexibility and ease of building 3D models varies from one tool to another.

Autodesk Ecotect interface was designed with architects in mind (ECOTECT, 2005). We can verify this from our experience that exceeds ten years of using and teaching Ecotect in School of architecture in the UK. It has one of the most user-friendly interfaces in comparison to older software such as DOE or ESP. It "is a highly visual architectural design and analysis tool that links a comprehensive 3D modeler with a wide range of performance analysis functions covering thermal, energy, lighting, shading, acoustics and cost aspects" Crawley et. Al (2008). Autodesk Ecotect allows easy construction and manipulation of 3D models in a way that fits more with the way architects work. User can import 3D computer models in *.3ds or *.dxf formats from several widely used computer aided design software such as AutoCAD, 3D Studio, Rhinoceros or Sketchup. Autodesk Ecotect version 5.6 is able to import and export gbXML. This facilitates more flexible communication with ArchiCAD and several other simulation and modelling tools (AUTODESK ECOTECT a, 2008). From experience Autodesk Ecotect's thermal simulation results are not fully representative of reality, although this is perhaps not an issue in case of parametric studies investigating the relative effectiveness of design options.

This is the main disadvantage of Autodesk Ecotect. This is due to the limitations of its thermal simulation engine which is based on the CIBSE Admittance Method (CIBSE, 1999). Autodesk Ecotect uses this method to calculate internal temperatures and heat loads. Admittance Method is a pseudo-dynamic method based on variation about the mean value. It also has the disadvantage of not taking in consideration the effect of solar radiation when it enters the space. Solar radiation is considered a space load the moment it hits a window and is not traced to check which internal surface it hits and accordingly heats up. Equally important Autodesk Ecotect can not calculate thermal lag for composite elements that are not included in its library. Although the Autodesk Ecotect materials library includes most of the typical components used in the building industry, it does not cover a wide range of materials used throughout the world, especially outside Western countries. This prevents the user from optimizing the construction of his proposed design and therefore inhibits one of the main aims of computer simulation. Thus it is advised to use more detailed thermal simulation tools in later stages of design process or research projects.

Autodesk Ecotect model can be exported to a wide range of well established detailed thermal modelling software such as ESP-r, EnergyPlus, DOE-2 and HTB2. The following is a brief discussion of the advantages and disadvantages of those tools.

ESP-r was developed at the Energy Systems Research Unit of the University of Strathclyde. It simulates the thermal, visual and acoustic performance of buildings. It can also be used to assess the energy use and run computer fluid dynamics (CFD) analysis. Its thermal simulation engine uses a finite volume conservation method. ESP-r was subjected to a substantial number of validation studies including inter-model comparisons and comparisons with monitored data (Strachan, 2000). ESP-r is designed for UNIX operating system but can run under Cygwin environment. This still requires an advanced level of proficiency in UNIX. Despite its graphical user interface, it is still very user unfriendly for architects and architecture students. It is thus unlikely to be used during architectural design.

EnergyPlus was developed by the U.S Department of Energy. It models heating, cooling, lighting, ventilating loads. It is based on DOE-2.1 and BLAST features. It reads input and writes outputs as text files with a very unfriendly user interface. Lately several interfaces were developed including OpenStudio. This is a free plugin for Google SktchUp; a 3D modelling software widely used in architecture practices and schools. The main limitation of Energy Plus is that it does not accept more than four sided thermal zones. Although this is not a prohibitive problem in the majority of cases, it is impossible to use Energy Plus to study non-rectangular shapes or non traditional designs.

HTB2 is a general purpose dynamic energy and environmental performance simulation tool. It is based on a simple Finite Difference Heat transport model (AUTODESK ECOTECT, 2008d) and can calculate internal temperature and energy use. It is "an example of a Detailed Simulation Programme or DSP. As such it is complex software and can require a considerable learning effort to achieve its full potential" (Alexander, 1996). It generates its own heat flow coefficients and response factors from the detailed information of the layers making up composite building materials. This overcomes Autodesk Ecotect's inability to calculate thermal time lag of composite materials. The main disadvantages of HTB2 are its inability to handle complex occupancy profiles and its inability to handle complex glazing and shading systems. In Previous work, Alexander et al (Alexander, Mylona, & Jones, 2005) looked into developing HTB2 algorithms to be able to handle calculating the effect of glazing and shading options such as slatted blinds. They modified the algorithm to be capable of predicting total solar transmission of glazing with mid-pane shading combinations.

HTB2 can be linked to several software tools such as Autodesk Ecotect and the air-conditioning system simulation program BECON. The later could be used in conjunction with HTB2 to assess the electricity consumption for air-conditioning systems. This was used for example by Yik et al (YIK F. W. H., JONES P., & J., 2008) to assess the electricity consumption for air-conditioning in high-rise buildings in Hong Kong.

No previous work was found to investigate the research problem that the current paper is trying to address; "using Autodesk Ecotect and HTB2 as modelling and simulation tools simultaneously". Only Marsh and Al-Oraier (Marsh and Al-Oraier, 2005) employed Autodesk

Ecotect in a previous work to build a model of a traditional adobe dwelling and exported it to HTB2 and Energy plus. They studied the issues associated with creating a base computer model in Autodesk Ecotect that is fully compatible with HTB2 and EnergyPlus simulation tools. They then compared the two outputs to the monitored data. They found reasonably close agreement between the simulated and monitored data. However, in some cases they found significant variation between the results of the two software tools and the measured data and between the results of the two software tools themselves. This close agreement between the simulated results and the measured data was unsupported quantitatively. Moreover, this work did not discuss the methods and constrains associated with exporting the model from Autodesk Ecotect to HTB2.

2. Research aims

This paper aims to investigate the techniques and precautions required when building and exporting Autodesk Ecotect 3D models to HTB2. This was done through comparing the simulation output with measured internal air temperature for models of five classrooms of three schools varied in computer description and detail.

With the necessity to strike a balance between accuracy, simplicity and flexibility, HTB2 is considered in this work as a suitable tool to be used in conjunction with Autodesk Ecotect. The reliability of the HTB2 simulation results depends on: 1) the accuracy of the data input; this includes the building geometry, material specification and weather data, 2) the method by which the Autodesk Ecotect model is introduced to HTB2. The later is the focus of the work presented in this paper. Being able to easily and quickly present the situation in question and yet generate reliable representation of real situations is an important factor in any simulation study. This work investigated the model setting and geometry to build a base computer model in Autodesk Ecotect that could be exported and simulated in HTB2 properly. Graphical and statistical tests will be employed to quantify the strength of the closeness between both the monitored and simulated sets of data.

3. Methodology and research climatic context

This work considers rules and procedures for importing Autodesk Ecotect models to the detailed thermal simulation software HTB2. The National Renewable Energy Laboratory empirical validation methodology in which the simulated results from HTB2 are compared to monitored data (Rittelmann and Ahmed 1985).

Geometric and physical descriptions of the three schools are modelled in Autodesk Ecotect and their performance simulated. The depth and complexity of the models are varied. The simulation output is then compared to measured data for the month of May.

To this end, five classrooms of three governmental primary schools built in al-Minya Governorate of the Arab Republic of Egypt (refer to Figure 1) were employed as a vehicle for the investigation these are a) Omer ebn al-Khatab school, b)Al-Lamaty school and c) Al-Shaheed school. **<insert Figure 1 about here>**

Egypt is situated in the northeast corner of Africa (27 00N and 30 00E). According to Köppen-Geiger climate classification system, Egypt lies in the warm desert climatic zone (Peel, Finlayson, & McMahon, 2007). The country is further divided into seven climatic design regions (EOECP, 1998). Al-Minya lies in the desert climatic design zone. This zone is the largest among the seven regions. It is characterised by large diurnal variation with typical average outdoor day air temperatures of 41°C and typical night average air temperature of 20.5°C in August, and typical average low outdoor air temperature of 4 °C in winter.

The three schools employed vary in size, form and orientation as shown in Figure 2 **<insert Figure 2 about here>**. However, all schools used the same structural and construction systems. All classrooms are rectilinear in shape with internal dimension of 8000mm x 5000mm (refer to Figures 3 and 4). **<insert Figures 3 and 4 about here>**

The internal air temperatures inside all the classrooms were monitored during May 2007; the hottest month of the academic year. This was done using Hobo U12 data loggers. Outdoor temperature ranged between 43.42 °C and 15.62 °C. Relative humidity ranged between 72.25% and 6.75%. External weather data during the same period were logged using a Hobo weather station to create a weather file that was used later in the thermal simulation.

The effect of 12 modelling and exporting conventions and rules provided by Autodesk Ecotect developer (Marsh, 2006, AUTODESK ECOTECT 2008 b-d) and HTB2 documentation (Alexander, 1996) on the effectiveness of communicating with HTB2 and the reliability of the simulation results, were investigated (sections 4.1 and 4.2). Further three modelling inputs were varied; the model size, voids construction and wall construction detailing.

Omer ebn al-Khatab classroom was modelled. Upon exporting the Autodesk Ecotect model to HTB2, an error occurred. Two reasons were found; the method of void construction and the model size (refer to sections 4.1 and 4.2). Upon resolving these issues the Autodesk Ecotect model was successfully exported to HTB2. Simulated internal air temperatures were compared to the monitored internal air temperatures graphically (Figure 9) and statistically using Mann-Whitney test. A significant difference ($p<0.05$) was found. A parametric analysis was conducted and it was found that the level of model details has a statistically significant effect on the reliability of the simulation results. The level of details that yielded internal air temperatures closest to the monitored data was further used.

To investigate the collective effect of all rules and particularly the effect of the proposed level of details, the other four classrooms were modelled using all rules listed. Once again the internal air temperatures of the classrooms were simulated using HTB2 and the results were compared statistically to the monitored data. Applying Mann-Whitney test on the simulated and the monitored temperatures suggested that the difference in all cases was not significant ($p>0.05$).

4. Modelling conventions and rules

4.1 Modelling for Autodesk Ecotect simulation

There are several methods of building a 3D model in Autodesk Ecotect. The choice depends mainly on the stage of the design process. The straight forward method is to build the model directly on Autodesk Ecotect. An alternative way is to import the 3D model from other software such as Sketchup, AutoCAD or Rhinoceros in DXF or 3ds format. This method will result in a very large file, which will affect the simulation speed. In other cases, exporting the 3D model from other software might result in a complex Autodesk Ecotect model, which will not be suitable for running thermal simulation. In case of lighting analysis, the user might want to model the building in details if this is expected to affect the simulation results. Another technique is to trace over a scanned hand drawn or computer sketch using either the centre line of the walls or the internal boundaries of each space to build the thermal zones. This method is expected to be very popular in architectural context as it allows checking a wide range of options very early on during the design process.

There are some general conventions that users have to adhere to when constructing a thermal model in Autodesk Ecotect (Marsh, 2006, Marsh 2008a, Marsh 2008b, Marsh 2008c). The following is a summary of those conventions:

1. Each zone must be drawn as an enclosed three dimensional prism with planner surfaces on all sides. In other words, each zone must be water tight volume.

Autodesk Ecotect will only consider a volume of space as a thermal zone if its surfaces fully enclose the entire volume;
2. Two zones are considered to be adjacent if they are parallel to each other and less than a specified distance apart known as adjacency tolerance. This must be adjusted to accommodate the separation distance as appropriate depending on the modelling technique applied;
3. All the types of elements and materials used have to be specified;
4. Each space of the building under investigation must be drawn as a separate zone;
5. If a space is adjacent to or includes another secondary space that exchange air with, then the secondary space could be added to the primary zone;
6. A large open-plan space with windows in several sides must be divided into several sub-zones;
7. The shared elements between two adjacent zones must be adjacent and overlapping;
8. External shading systems must be placed on a non-thermal zone so as not to contribute to the thermal zone;
9. In order for Autodesk Ecotect to recognize the orientation of each surface, especially in very complex models, the normals of all the surfaces must point outwards.

If a model is drawn in Autodesk Ecotect properly, the thermal simulation will run smoothly. However, not every Autodesk Ecotect model will successfully be exported to and simulated by HTB2.

4.2. Modelling for exporting to HTB2

There are several sets of limitations that must be adhered to during Autodesk Ecotect model construction to successfully communicate with HTB2. According to Autodesk Ecotect documentation (AUTODESK ECOTECT, 2008c) there are three main rules:

1. The number of windows in a model being exported to HTB2 must not exceed 100. HTB2 is a FORTRAN program and all its array sizes are predefined. This means that HTB2 can only store 100 shading masks hence the limitation on the number of windows. If the model contains more than 100 windows, HTB2 file can be edited manually to use the same shading masks for the windows facing the same orientation. Another approach would be to amalgamate several separate windows in the same wall into a single window as shown in Figure 5;
   <insert Figure 5 about here>
   In addition, HTB2 documentation adds the following limitations:
   a. 100 modelled and 3 un-modelled spaces;
   b. 25 construction types, using a total of 100 parts;
   c. 25 window types and 100 shading masks;
   d. 600 elements, with 9000 fabric nodes;
   100 heating systems.
2. Each window must be assigned to the object onto which any direct solar radiation will fall. By default Autodesk Ecotect assigns this to the floor of the zone in which the window is located. If Autodesk Ecotect is unable to find an associated floor object, it will choose the nearest zone object and generate a warning message;
3. HTB2 does not use the thermal properties of composite elements that Autodesk Ecotect generates. Instead it generates its own heat flow coefficients and response factors from the detailed layers information. If the properties of any layer used to

build up a material in Autodesk Ecotect are not accurate or not specified, HTB2 will generate an error message and the exporting process will be aborted;

5. Convention and rules application

One case study - Omar ebn al-Khatab – was modelled in Autodesk Ecotect taking in consideration all previously mentioned conventions. On exporting the model to HTB2, numerous error messages were displayed and the exporting process was stopped. The error messages in most cases did not provide enough guidance on how to fix the faults in the model. For example, when an Autodesk Ecotect model including a curved surface drawn as an arch was exported to HTB2, the process was stopped, and the following error message was displayed: *ERROR: RDLAY: inappropriate surface area has been specified.* It was not clear from this message which surface caused the error and why it was inappropriate. Accordingly a parametric analysis was conducted to pinpoint the cause of error. Two reasons were found: 1) model size, 2) the method of voids construction and modelling technique developed that overcame these errors.

5.1. Model size

In some cases, it is difficult not to exceed the limitations on the number of model elements especially the restriction on total number of elements of the model (refer to point 4 under section 3.2). The model of any multi-storey building could easily exceed this limit if built to a reasonable level of details. The current work proposes several recommendations to reduce the total number of elements while maintaining a fair level of reliability. Those recommendations could be summarised as follows:

1. It is important to include the overshadowing effect due to surrounding buildings. However, modelling the surrounding buildings could substantially increase the total number of elements in the model. To avoid this it is proposed to reduce the details of the surrounding buildings by representing several adjacent blocks as one zone as shown in Figure 6 **<insert Figure 6 about here>**;
2. Reduce the details of the adjacent zones by using larger non-thermal zones as shown in Figure 7. "Autodesk Ecotect v5.50 will make any surface that is adjacent to one or more planar objects on a non-thermal zone into an *adiabatic surface* i.e. has no heat flow through it" (AUTODESK ECOTECT, 2008b). This is valid in the case of, for example, a terraced house or a multi-storey building. In theses cases the heat flow from adjacent zones could be ignored assuming that the temperatures inside them will be roughly the same as the zone under investigation **<insert Figure 7 about here>**;
3. Every partition is created with a construction line to allow the manipulation of its shape. These lines become of no use after completing the model and unnecessarily double the number of partitions in the model. Therefore, it is advised to delete those lines before exporting the model to HTB2.

5.2. Voids construction

In two of the case studies, the classrooms are arranged on a linear single sided corridor exposed from one side to the elements as shown in Figure 3. One way of modelling this in Autodesk Ecotect is to construct a zone representing the corridor and then insert a void in the external walls as shown in Figure 8a. HTB2 requires the detailed layer information of each object. Since void is not built up of layers, HTB2 could not handle it. Hence, an error message saying that there is an unknown source for the void layer was displayed when the model was exported from Autodesk Ecotect to HTB2. To overcome this problem the wall could be deleted and either build as three partition (figure 8b) or as a single plane as shown in Figure

8c. It is advised to use the later technique in order to keep the total number of the elements in the model as minimum as possible. It is to be noted that this plane must be in the same zone and should be assigned a wall material. **<insert Figure 8 about here>**

Based on the above, the Autodesk Ecotect model was successfully exported to HTB2 and the thermal simulation was conducted. In order to validate the simulation results, the hourly simulated and monitored data were compared as shown Figure 9. Applying Mann-Whitney test on the data revealed a significant difference ($p<0.05$), despite the two sets of data trends being consistent. **<insert Figure 9 about here>** One reason for this could be the fact that walls are constructed of different materials of different thicknesses as shown in Figure 10. Further work was conducted to investigate the effect of the model level of details on the accuracy of the simulation results. **<insert Figure 10 about here>**

6. Effect of model details on the simulation accuracy

In order to investigate the effect the model level of details on the simulation accuracy, a parametric analysis was conducted to optimize the level of details without jeopardizing the accuracy of the results. The first case study was modelled using the following four methods as follows:

Method 1. All walls of all zones are drawn in full details. That is to say, every part of the wall is drawn as a single plain or partition and is specified a specific material;
Method 2. Only walls of the zone under investigation are drawn in full details with the rest of the building's walls drawn in a simple manner. The later means, drawing the wall as a one element using the material properties of its largest section;
Method 3. Only the zone under investigation is drawn in a simple form with the rest of the building drawn in full details;
Method 4. All zones are drawn in simple form.

Figure 11 presents the HTB2 simulated internal air temperatures inside the classroom generated using the above four modelling methods. The simulated temperatures were then compared to the monitored data. Applying one way ANOVA test ($F=205.39$) on the data revealed that the mean internal air temperatures inside the four cases are significantly different ($p<0.05$). Applying Post Hoc LSD test on the data revealed that there is a significant difference ($p<0.05$) between the simulated internal air temperature and the monitored temperature in all cases except in case of using the second modelling method. **<insert Figure 11 about here>**

7. Results

In order to validate the proposed conventions and rules in terms of the simulation results accuracy, the other four case studies were modelled using the second method as described above. Models were then exported to HTB2 and the thermal simulation was performed. The simulation results were compared statistically to the monitored data using Mann-Whitney test. Analysis of results suggested that the difference between the simulated and the monitored temperatures in all cases is not significant ($p>0.05$) as shown in Table 2. Figures 13-16 graphically present a comparison between the simulated and monitored data inside the four case studies. They indicate a consistent trend of both sets of data.
<insert Figures 12-16 about here>

This paper presented an investigation into the techniques and precautions required when exporting 3D model generated by the whole building analysis software tool Autodesk Ecotect to the detailed thermal simulation software HTB2. It was concluded that there are fifteen precautions/techniques required to guarantee the accuracy of the thermal simulation (refer to sections 3-5). This conclusion was validated using five case studies (refer to section 6).

8. Conclusion

It is shown that the accuracy of the computer simulation output is affected by the level of detail included in the geometric description input.

In the case of Autodesk Ecotect when used to describe classrooms in Egypt to the HTB2 simulation it was found that there are fifteen modelling rules that should be adhered to ensure the accuracy of the simulation results.

9. Further work

During the course of this work, four main gaps in the knowledge were identified that further work will address. These are:

1. The effect of weather files type (on-site monitored weather data, typical metrological year or synthesized) on the accuracy of the thermal simulation;
2. The generation of weather file from outdoor data logged on site;
3. The effect of modelling techniques and computer processing powers on the duration of simulation;
4. The effect of the simulation engine (admittance method verses Finite Difference Heat transport model) on the simulation accuracy.

9. Acknowledgment

The authors would like to thank the Egyptian Ministry of Higher Education for the full PhD scholarship granted to the second author; Mr. Mady Mohamed. The later is an assistant lecture on a sabbatical leave funded by Zagazig University. Mr. Mohamed would like to thank the Zagazig University and the Egyptian Government for their financial support and the Egyptian Education and Culture Bureau in London for their effort in managing his scholarship. He would also like to thank Dundee School of Architecture for the continued support. Thanks are also due to Mr. Don Alexander of the Welsh School of Architecture for providing the authors with HTB2.

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11. Figures and tables

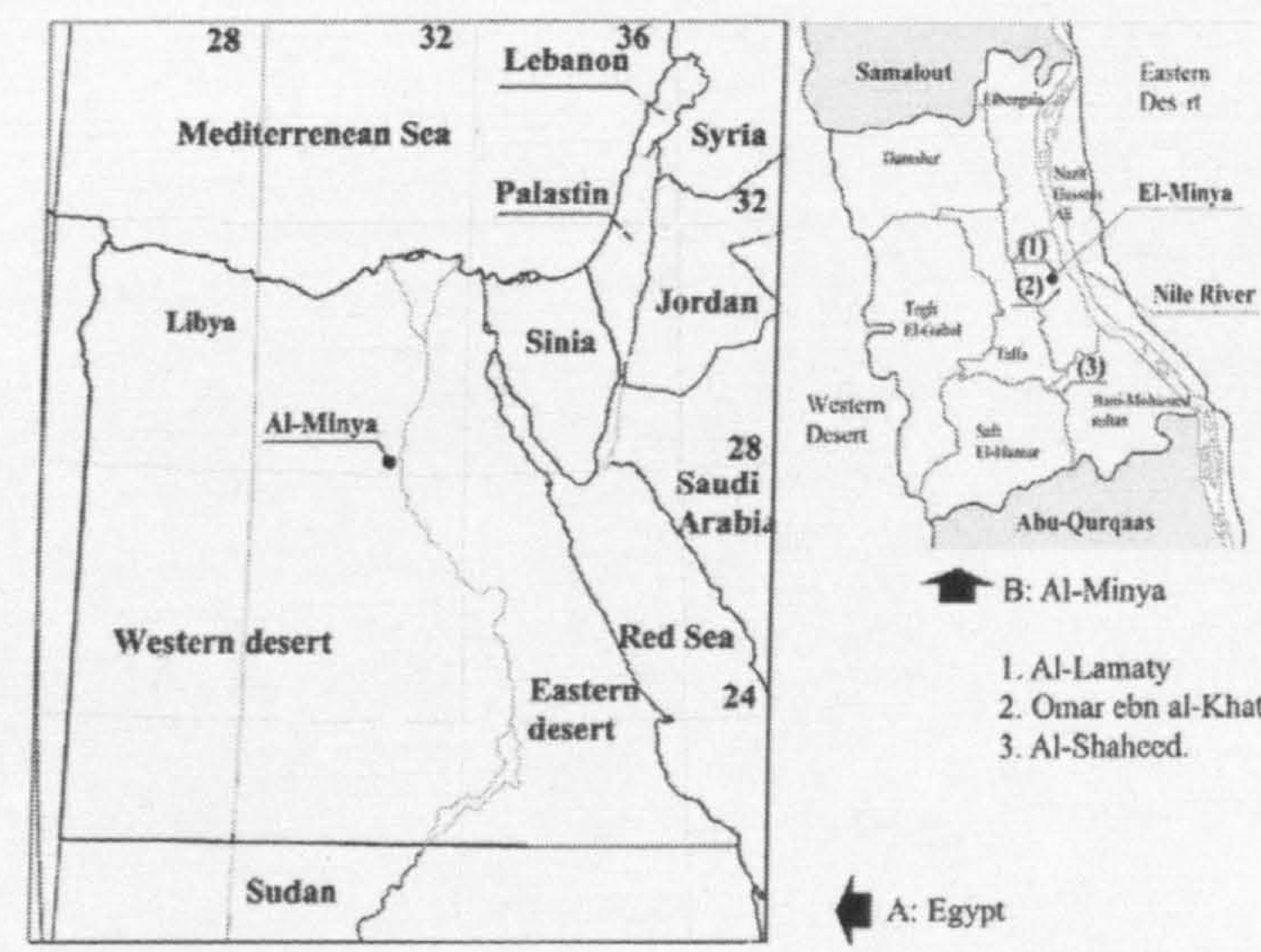

Figure 1: *a) Map of Egypt with the location of al-Minya, b) Case studies location in al Minya: 1- al-Lamaty 2 – Omar ebn al-Khatab 3- al-Shaheed*

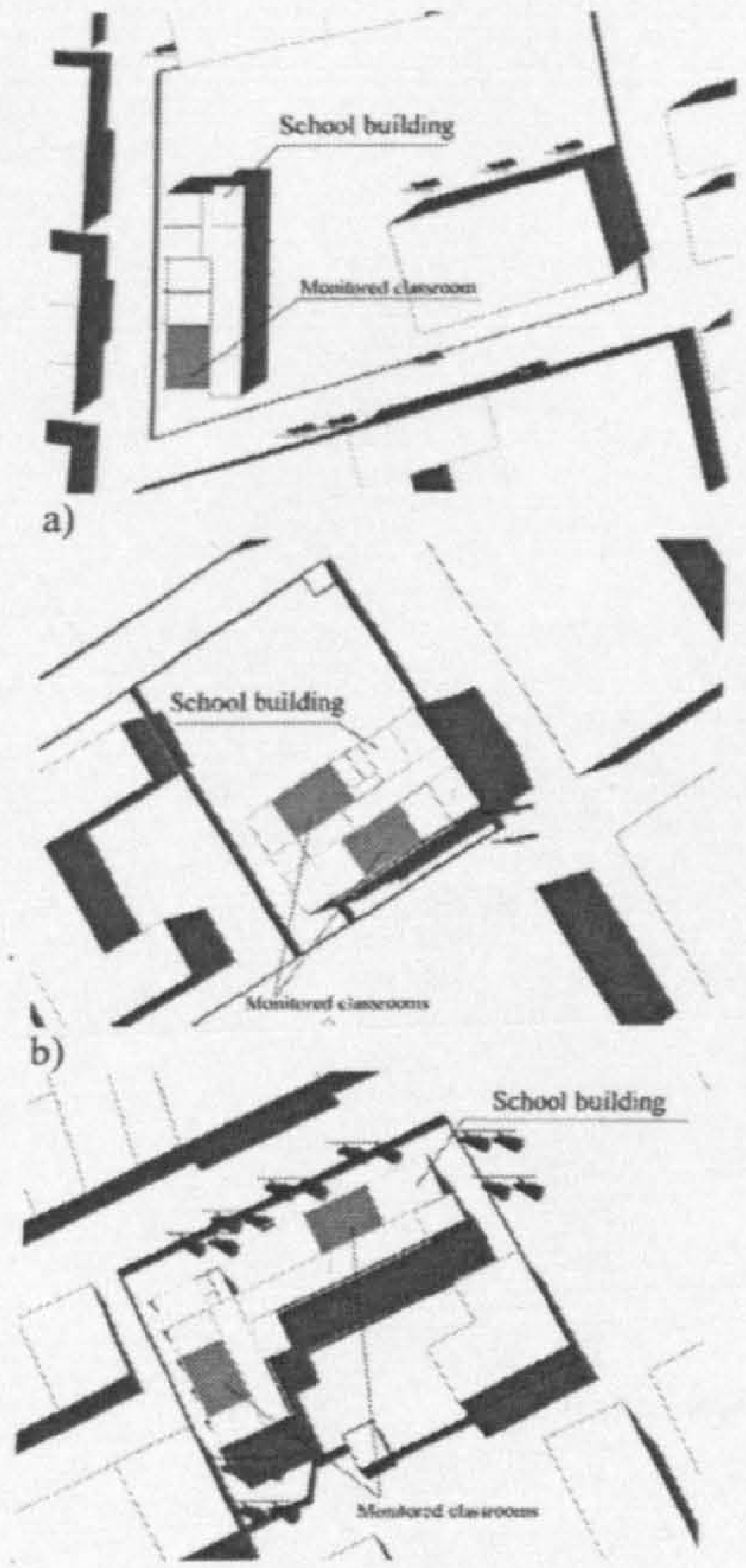

Figure 2: a) Omar ebn al-khatab, b) Al-Lamaty, c) Al-Shaheed.

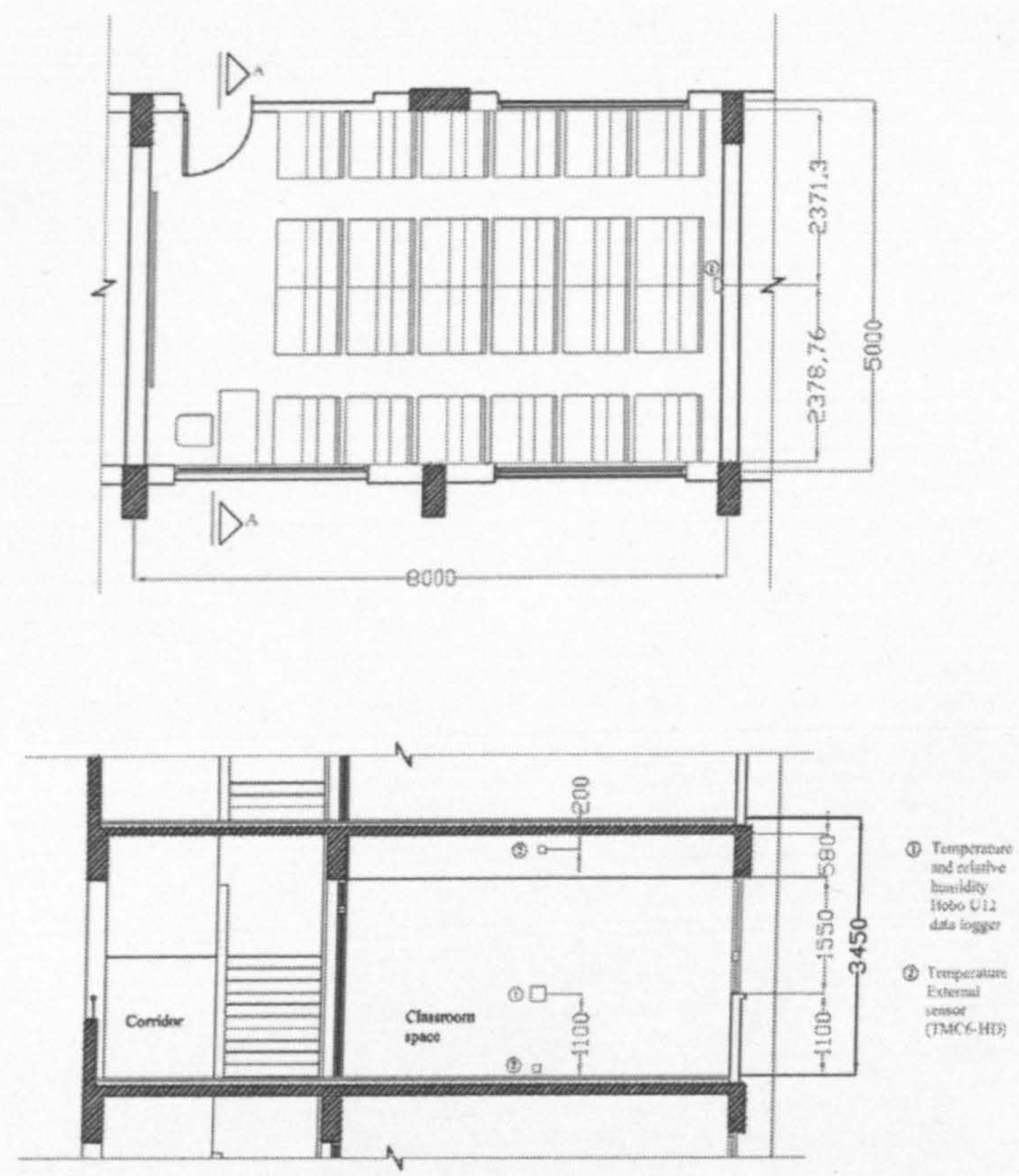

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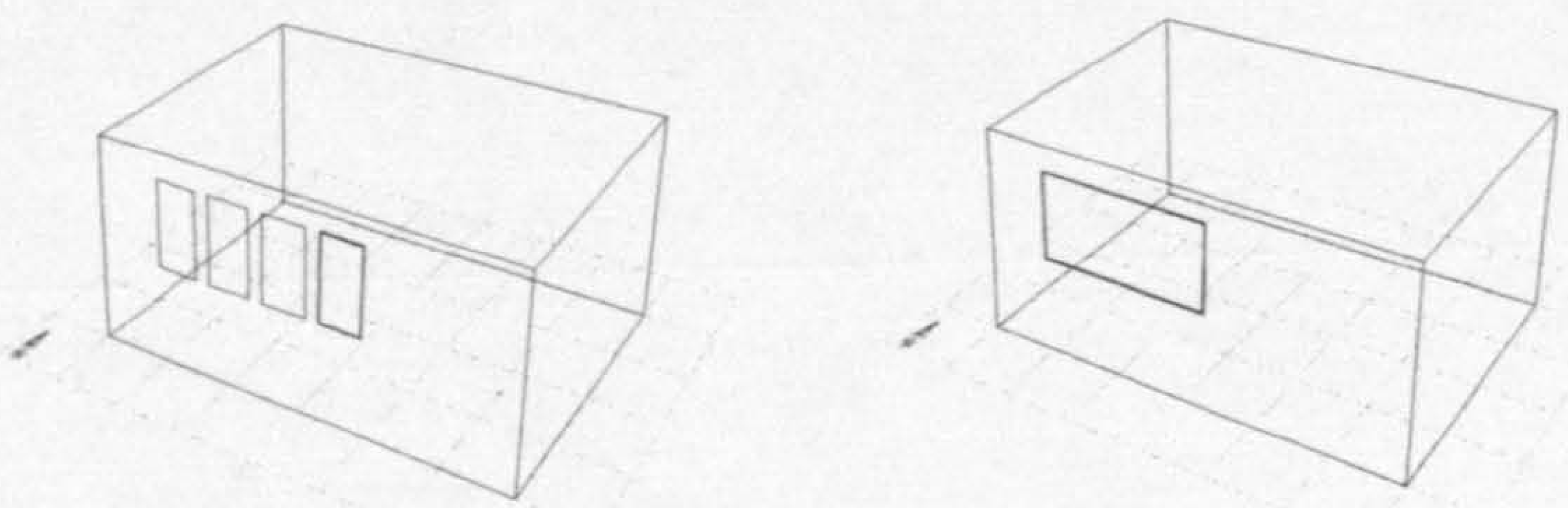
Figure 4: External and internal views of El-Lamaty primary school.



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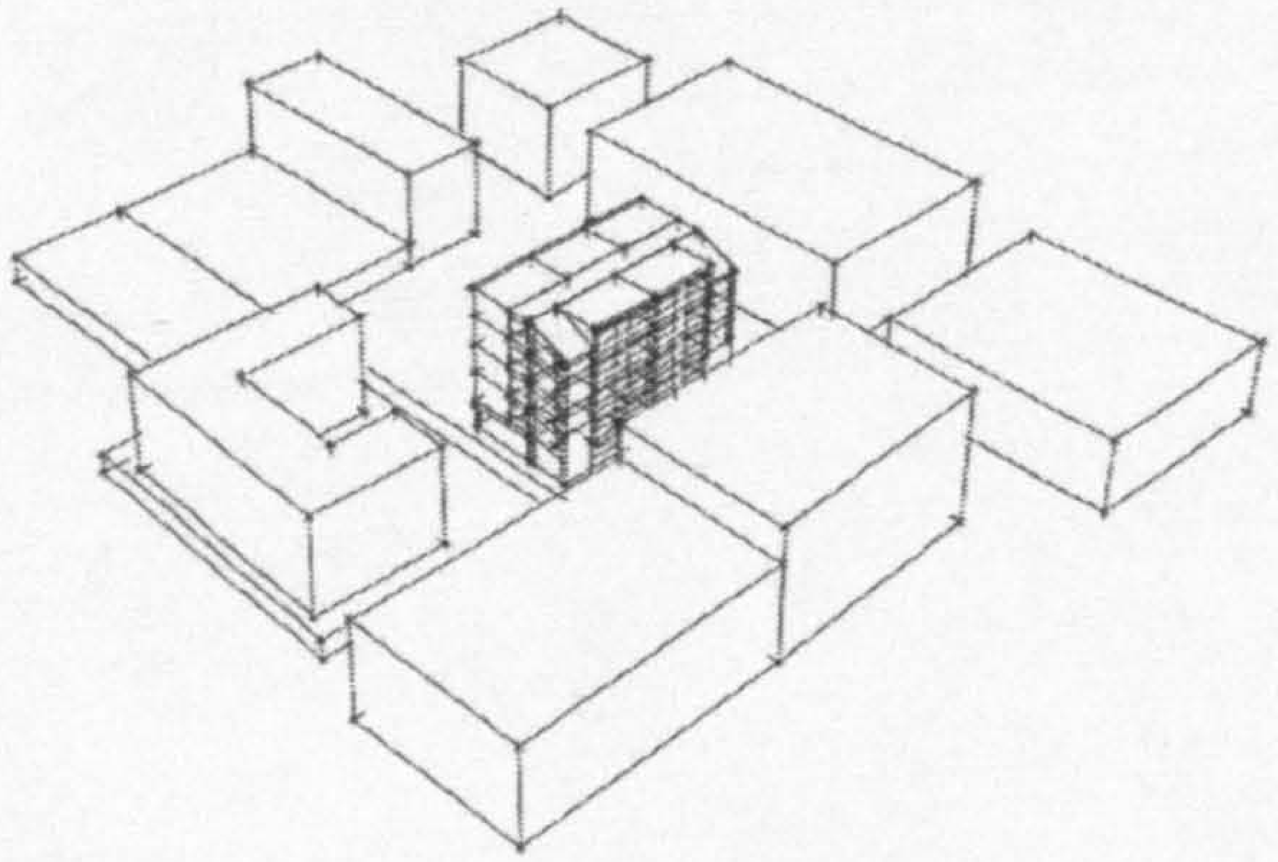

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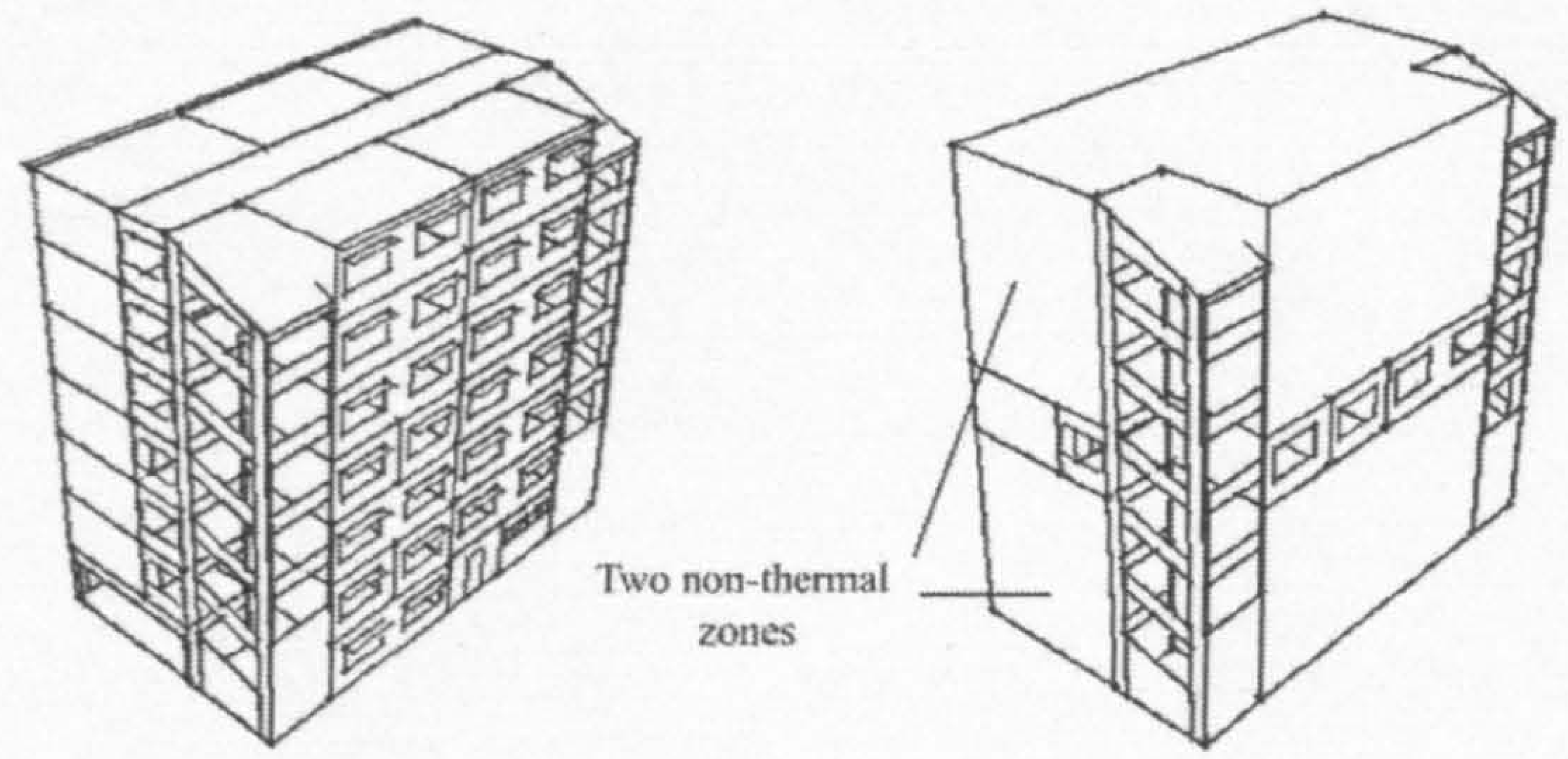


Figure 7: Reducing the number of elements of a multi-storey building.

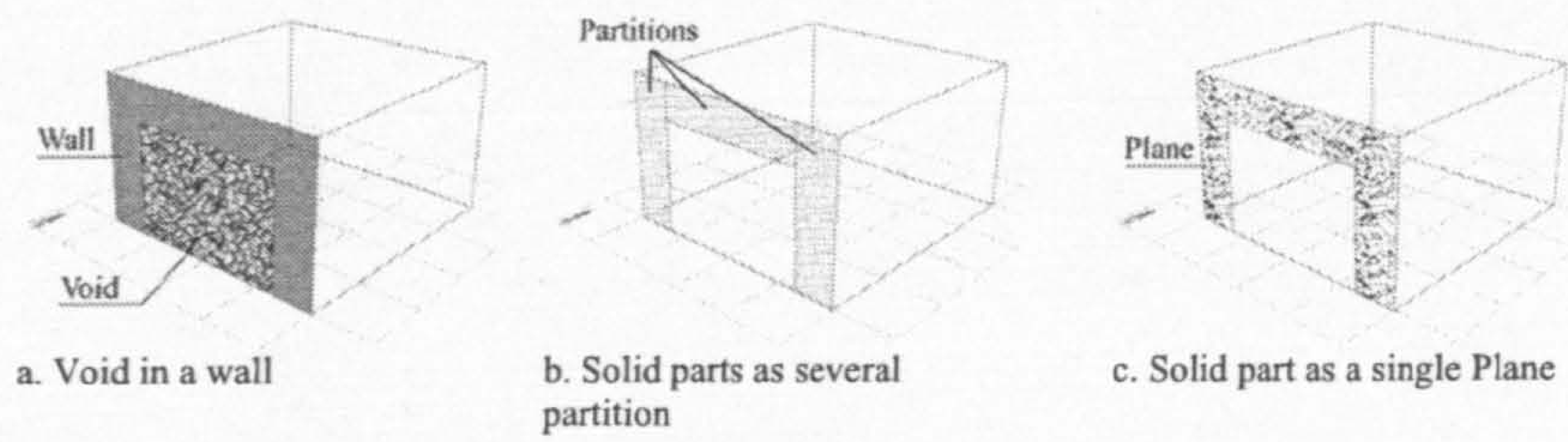


Figure 8: Techniques of building a void in Autodesk Ecotect.

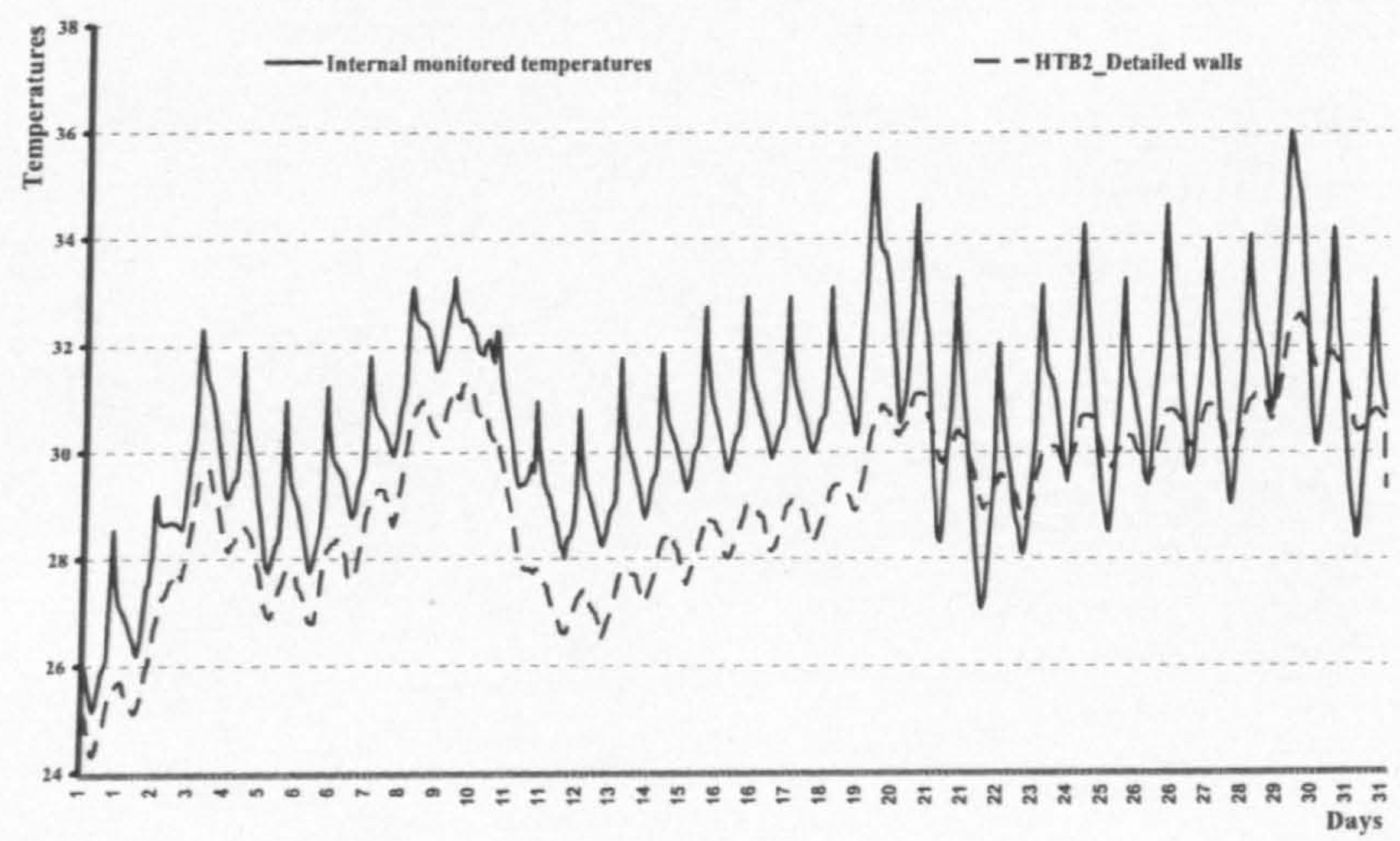
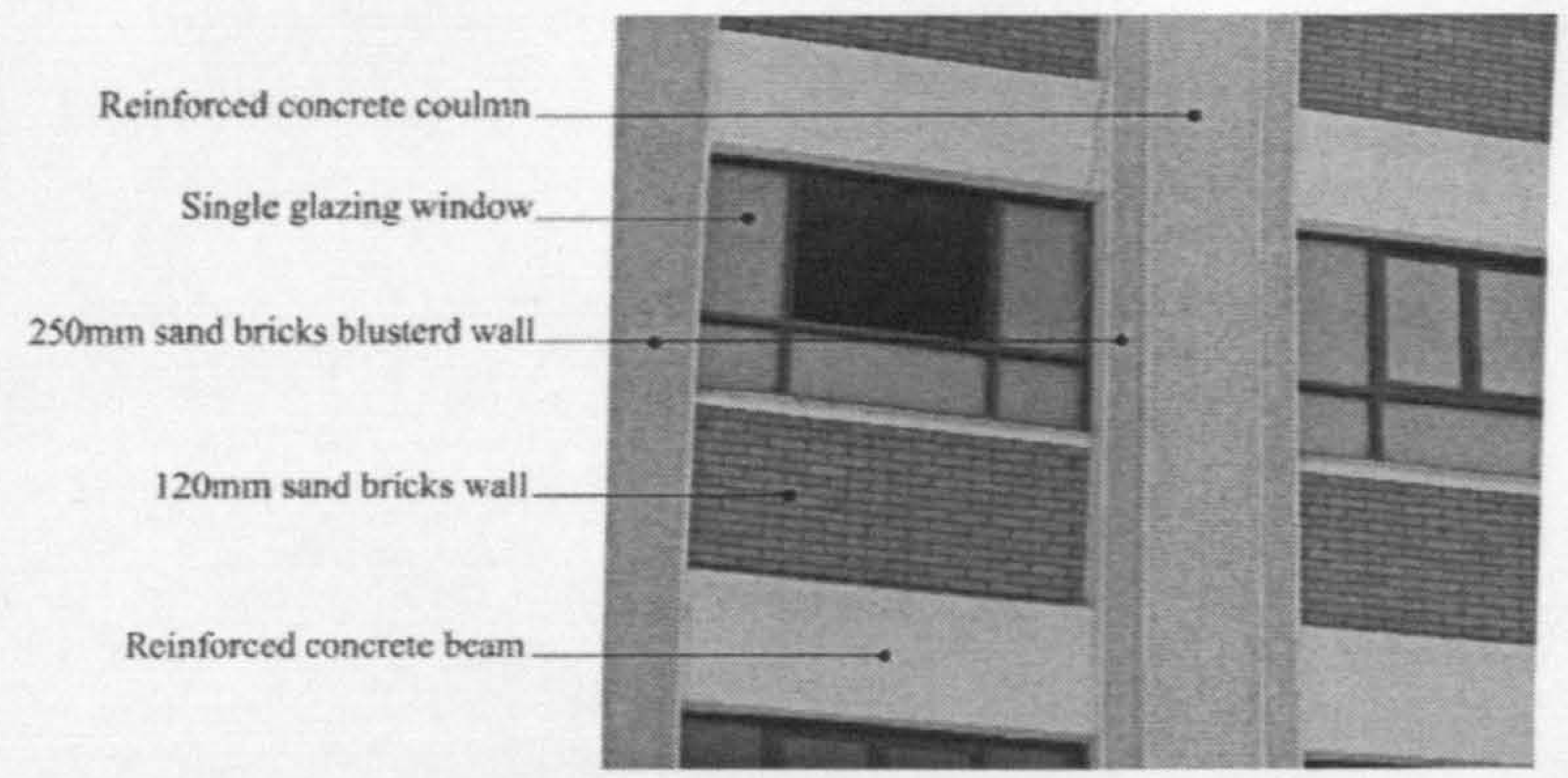


Figure 9: The internal monitored air temperatures compared to the HTB2 simulated air temperatures.



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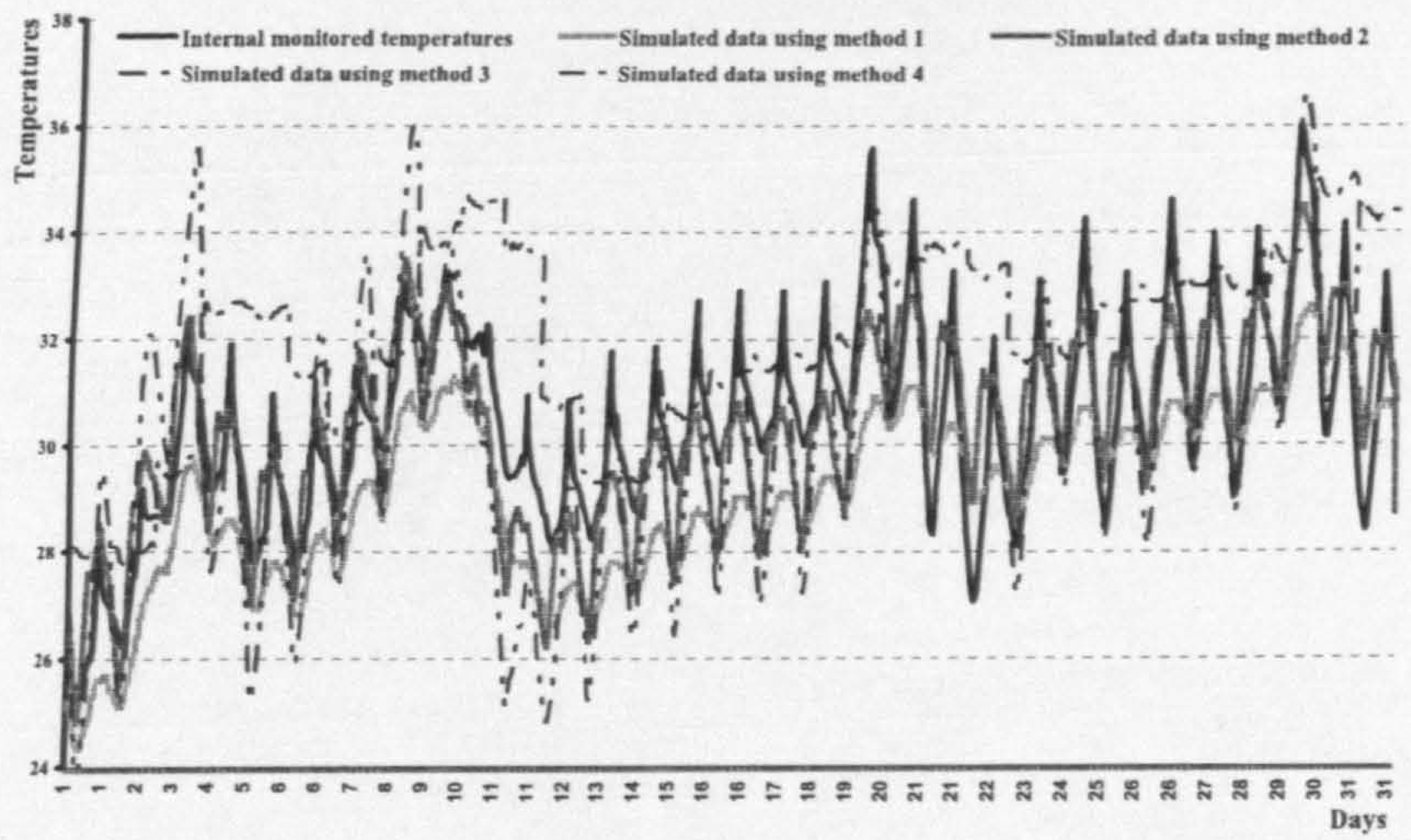

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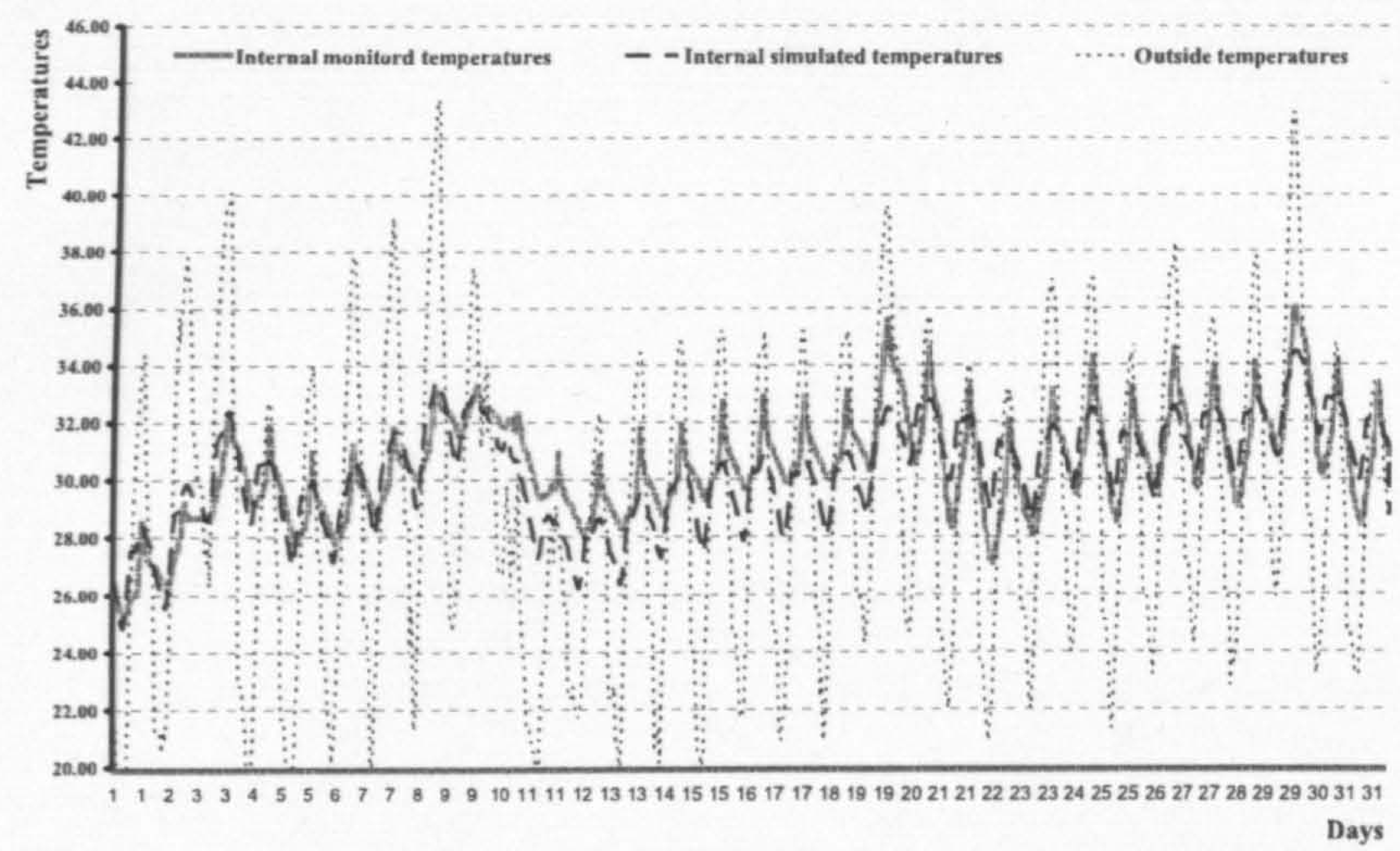

Figure 12: *Internal simulated air temperature generated using the proposed wall modelling technique compared to the monitored internal air temperature inside Omar ebn al-Khatab classroom (Classroom 1).*

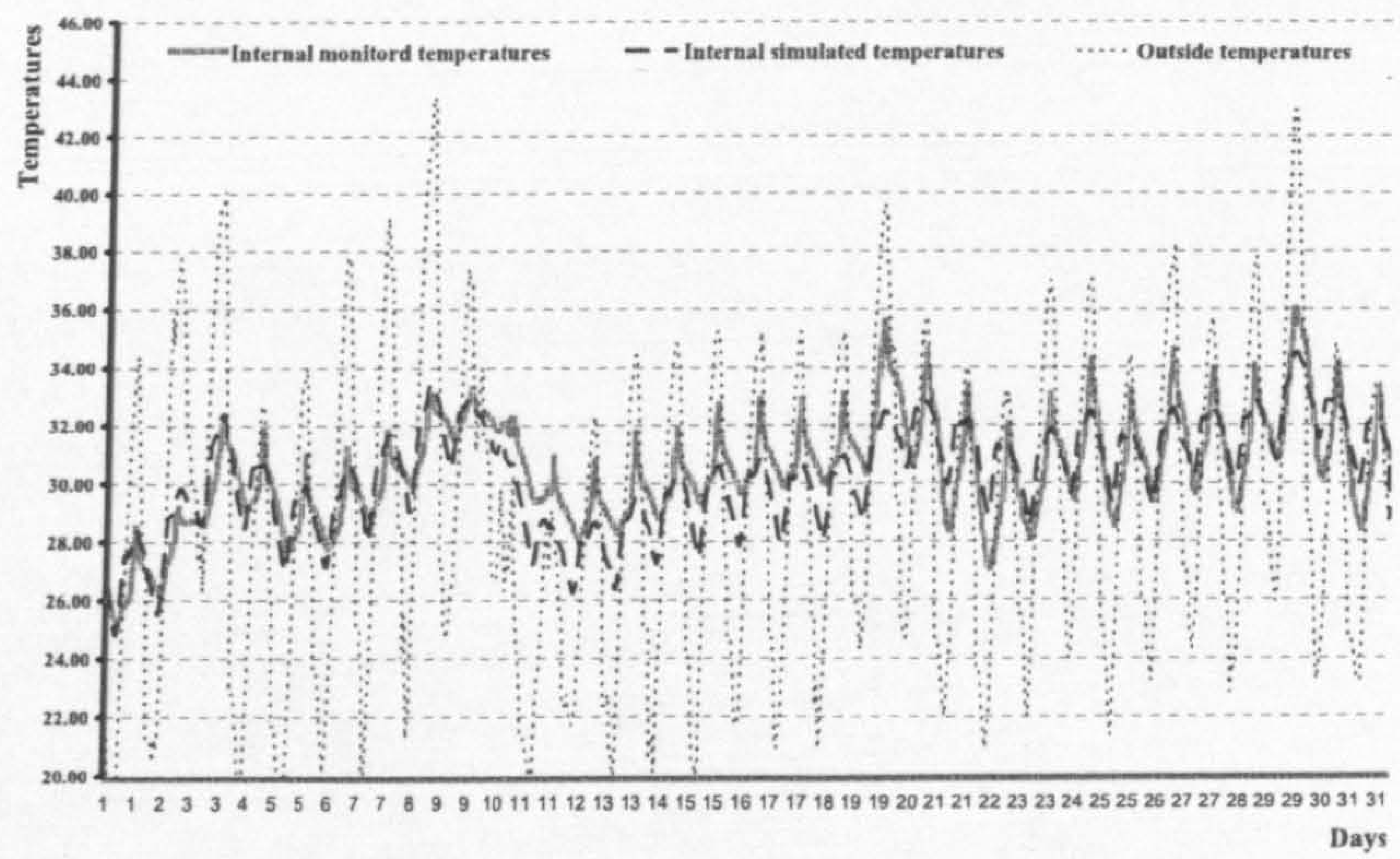

Figure 13: *Internal simulated air temperature generated using the proposed wall modelling technique compared to the monitored internal air temperature inside al-Shaheed classroom (Classroom 2).*

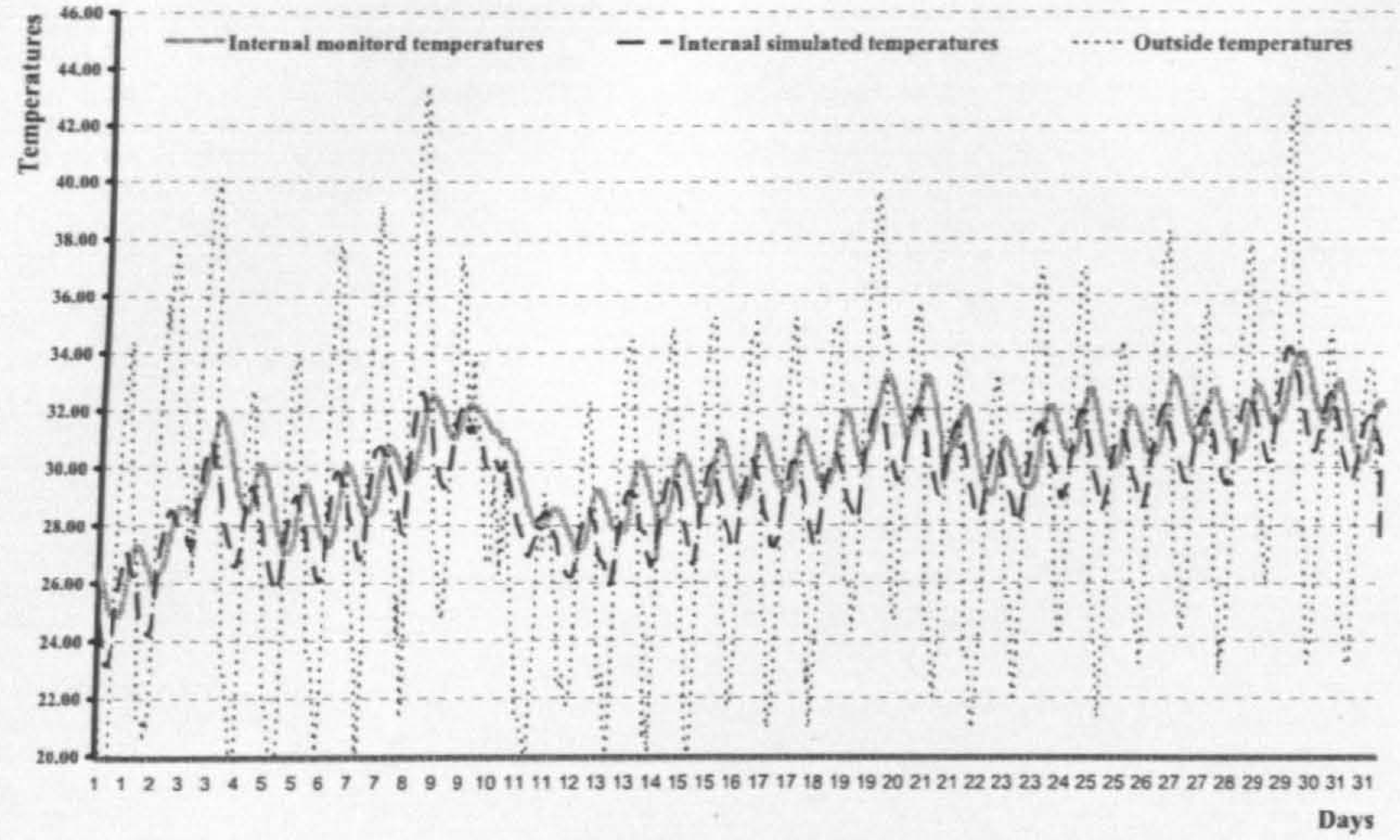

Figure 14: Internal simulated air temperature generated using the proposed wall modelling technique compared to the monitored internal air temperature inside al-Shaheed classroom (Classroom 3).

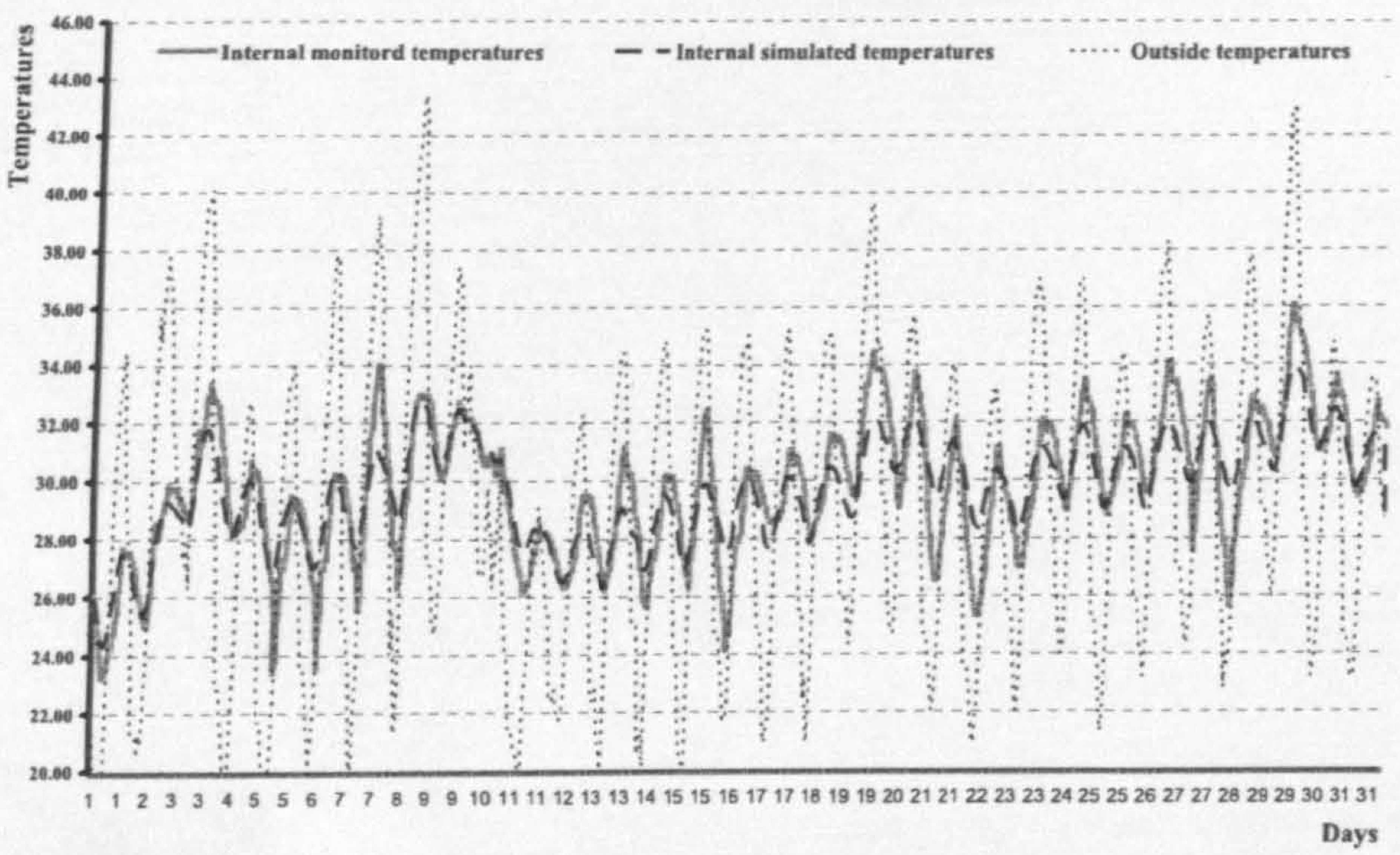

Figure 15: Internal simulated air temperature generated using the proposed wall modelling technique compared to the monitored internal air temperature inside al-Lamaty classroom (Classroom 4).

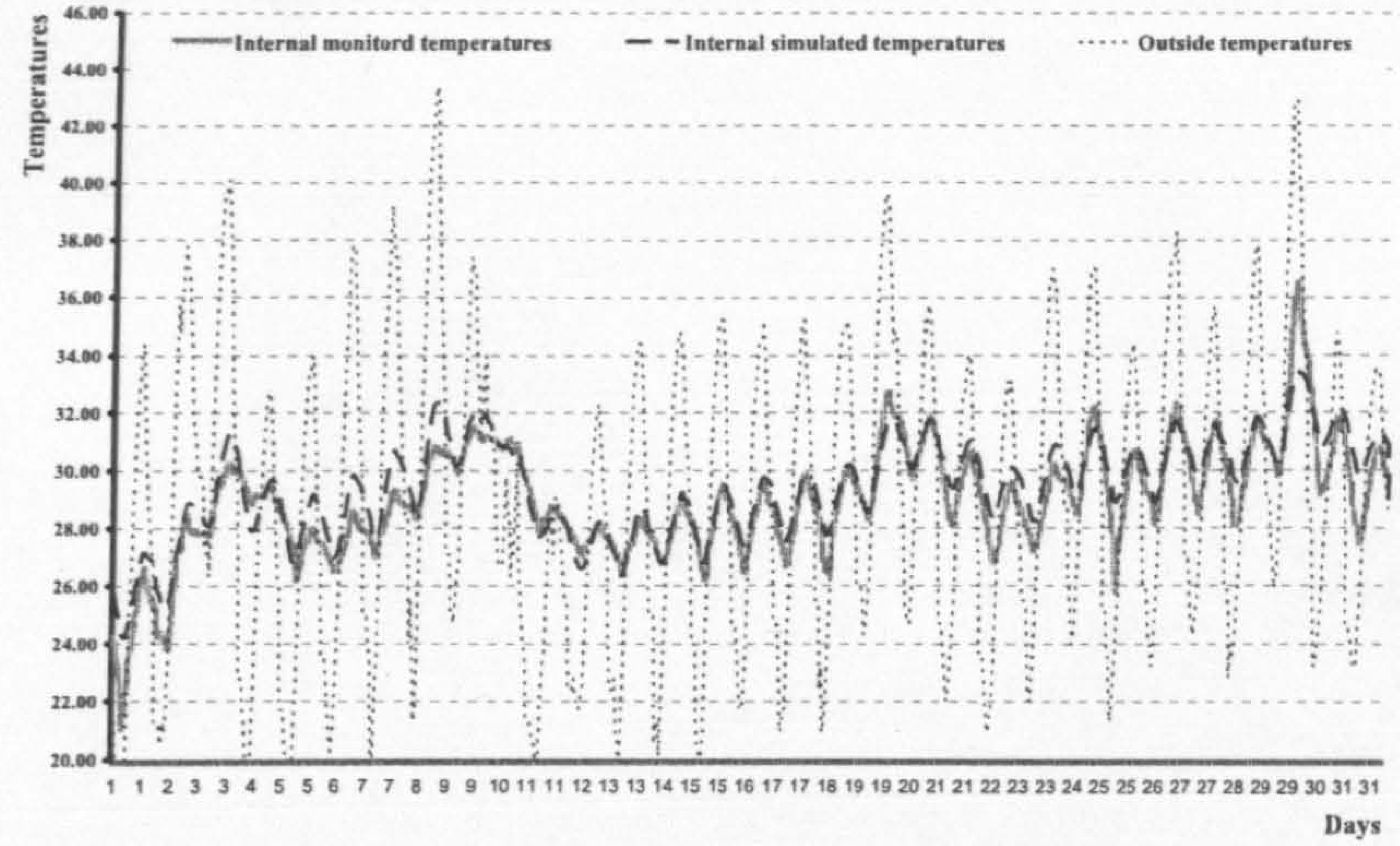

Figure 16: Internal simulated air temperature generated using the proposed wall modelling technique compared to the monitored internal air temperature inside al-Lamaty classroom (Classroom 5).

Table 1: The effect of wall modelling techniques on the accuracy of the simulated internal air temperature.

	Internal air temperature				
	Monitored	Simulated using method 1	Simulated using method 2	Simulated using method 3	Simulated using method 4
Mean	30.47	29.10	30.28	31.98	30.25
SD	1.84	1.64	1.78	1.78	2.57
ANOVA			F=205.389, P=0.005 Significant		

Table 2: Validation of the all conventions and rules.

	Primary schools employed as case studies									
	Omar ebn al-Khatab		Al-Lamaty				Al-Shaheed			
Classroom	Classroom 1		Classroom 2		Classroom 3		Classroom 4		Classroom 5	
M=Monitored temp. S=Simulated temp.	M	S	M	S	M	S	M	S	M	S
Mean internal temp.	30.47	30.28	29.75	29.67	28.99	29.43	29.26	27.75	30.17	29.31
SD	1.84	1.78	2.38	1.74	1.91	1.66	1.50	2.08	1.81	1.92
Mann-Whitney test	P=0.22		P=0 06		P=0.10		P=0.39		P=0.06	
The difference between the monitored and simulated internal air temperature	ns		ns		ns		ns		ns	

Paper 6:
The eastern Sahara earth construction techniques: A case study from the western desert of Egypt

The eastern Sahara earth construction techniques:
A case study from the western desert of Egypt

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Abstract: Traditional building techniques such as earth construction began to decline in Egypt and specifically in the western desert oases. This paper presents an investigation into the potentials and constrains of reintroducing earth construction techniques in four out of six desert oases forming the New Valley Governorate; Baharia, Farafra, El-Dakhla and El-Kharja. Two field studies were undertaken. The first took place during a research trip that included Cairo, Giza, the four oases and Luxor during October 2006 and the second was conducted in El-Dakhla during April 2007. A total of eighteen in-depth interviews were carried out employing locals from different social backgrounds. The results suggest a strong possibility of reusing earth construction techniques in the four oases. However, a number of limitations were identified, including; durability, buildability and the attractiveness of the mud architecture to the locals. Validation of the results and addressing those constrains will be the focus of future work through assessing the thermal performance of vernacular and modern case studies in the oases.

Key words: Sahara, Earth construction, Mud, Egypt, Oasis

1. Introduction

Earth construction techniques have been in use in deserts around the world for thousands of years. Mud or clay was traditionally used in different ways as a building material. Earth is layered in formworks forming walls as in rammed earth buildings, or shaped into rectangular forms of different sizes to produce blocks that are then sun-dried, fired or compressed (manually or mechanically) to form green or unbaked adobe, fired bricks or comprised air blocks. Using mud as a building material has its own advantages and disadvantages. On one hand, mud has a weak water resistance, and can shrink after drying causing cracks. On the other hand, it is environmentally sustainable material. In most cases it is sourced locally. Its production, installation and maintenance use considerably low amounts of energy in comparison to modern construction materials and techniques; hence its low embodied energy. The heavy thermal mass, a common characteristic of earth buildings, compensates the low heat resistivity of the mud walls by dampening the temperature troughs and peaks, leading to substantial energy use reduction. In addition, an earth wall absorbs moisture from the air causing humidity balance inside spaces. Mud is also economically sustainable building material. In developing countries, the cost of a medium house built in mud is considerably lower than the same sized house built in reinforced concert and fired bricks. This is a very vital factor in developing countries where resources are very limited and the need for basic shelter is considerable.

The world deserts occupies about 25% of the total land area of Earth [1]. Global climate change, overgrazing, drought, and the rapid change of the socio-economical patterns of the pastoralists are all factors leading to desertification around the world. Perhaps the southern Sahara and the Sahel region is the most suffering region of all the world deserts. The Sahara (a word derived from the Arabic word *as-sahrā'* meaning wilderness) is the world's largest desert with an area of almost 9.1 million square kilometres [2]. It is formed of several deserts; distinct in nature and landscape (eastern, central, southern, northern and atlantic sahara) covering the whole of Northern Africa. It stretches from the Atlantic Ocean in the West to the Red Sea in the East, and from the semi-arid Savanna (the Sahel Belt) in the south to the Mediterranean Sea in the North. It fully covers several countries: Mauritania, Moroco, Algeria, Tunisia, Libya and Egypt, and partially covers Sudan, Mali, Niger and Chad. The majority of those countries are members of the Arab League where the Sahara is known as The Great Desert (Arabic: *as-sahrā' al-kubra*). Due to several factors the area of the Sahara is expanding annually to the south taking over the Sahel.

The western desert of Egypt (western desert will be used hereafter to describe the Egyptian western desert), a part of the eastern desert of the Sahara, was chosen as a geographical limit of the current work presented in this paper. A number of communities were visited to explore traditional earth construction techniques in use.

2. Research context

Egypt occupies the North East top corner of the African continent. It is bounded by the Mediterranean Sea from the North, the Red Sea, Israel and the Gaza Strip from the East, Libya from the West and Sudan from the South. Its total area is just over one million square kilometres. Only 4% of the land is inhabited and the rest is hot arid land divided into seven climatic design zones. The desert to the west of the Nile Valley is known in Egypt as the western desert (Arabic: as-sahrā' al-gharbia). It covers two-third of Egypt's total area. It spanes from the Mediterranean Sea in the north to the Sudanese borders in the south (

Figure *1*). The western desert is characterized by arid climatic conditions with extremely high temperatures and almost no rain and a very high diurnal difference throughout the year that ranges between 15.3°C in September and 17.7°C in April. According to the Egyptian Meteorological Authority [3] the average maximum temperature in Siwa in the north of the desert ranges between 19.5°C in January and 37.9°C in July while the average minim temperature ranges between 5.2°C in January and 21.4°C in July. The temperature increase as we go south until we reach El-Kharja in the south where maximum temperature ranges between 22.3°C in January and 39.6°C in August and average minim temperature ranges between 5.9°C in January and 23.7°C in July. El-Kharja receives some rainfall during January and December that does not exceed 0.2 mm/month.

3. Earth construction techniques

Ancient Egyptians used eleven types of stone beside sun-dried clay-rich Nile mud to build their sacred monuments and houses. Mud continued to be used in Egypt as a building material since then. While earth construction techniques are being developed in industrial countries and other developing countries such as France, Germany and India, modern building techniques using mainstream materials and technologies such as reinforced concrete and fired bricks have widely replaced earth construction throughout Egypt. The western desert is no exception with buildings being built using similar techniques used across the Nile Valley cities despite the difference between the two environments.

Medieval mud villages in the western desert are characterized by a compact urban form with narrow winding shaded streets as shown in

Figure *2*. Al-Dakhla for example was divided into zones; each encompasses the houses of an extended family with sometimes large areas for meetings and festivals. Ownership of land and the nature of social relations traditionally dictated the urban development of the villages. Most of the houses were attached from two or three sides with few buildings built around small courtyards. Some houses were built up to four stories high using silt and timber. Smaller houses used mud bricks (60 x 100 x 200 mm) made of surface soil mixed with fine sand and straw (*known locally as Tebn*). Walls were then rendered with silt.

It is believed that recently several technical, social, economical and political factors had played a great role in causing traditional urban forms and the unique mud architecture of the western desert to diminish. The majority of locals we have meat expressed their fears that this is changing the nature of the social structures of their communities and is changing the way relationships among their community members are developing. This work explored the factors that affected the use of earth construction in four of the western desert oasis; Baharia, Farafra, El-Dakhla and El-Kharja.

Perhaps the two most prominent architects who had started the development of earth construction techniques in Egypt is Hassan Fathy and Ramses Wissa Wasef. Fathy pioneered modern earth architecture in Egypt in the early twenties of the last century.

Fathy was followed by several architects who adopted the same approach such as Abdel Wahid El-Wakil, Ahmed Hamed, Rami El-Dahan, Hany El-Menyawy and Gamal Amer.

4. Research problem and previous work

The problem at the heart of the current research presented in this paper is that the use of earth construction techniques and materials that have the potential of providing a wide sector of Egyptians with much needed decent shelter is declining across the country. The western desert is one of the regions where earth construction was used for hundreds of years. Economically and environmentally unsustainable reinforced concrete construction techniques are used instead. In the harsh climatic context of the desert, thermal performance of the concrete houses is expected to be very poor in comparison to earth buildings. A review of literature revealed that very little is known about the potentials and constrains of using earth materials and construction techniques in Egypt including the new valley where traditional precedents of mud buildings can set a very good example for future development of earth building technology.

In an attempt to investigate the effect of building material and form on the environmental performance of interiors, Fathy employed two case studies of the same volume built in Cairo [4]. The first was constructed in 500mm thick earth walls and covered in mud vaults. The second was constructed in 100mm prefabricated concrete walls covered with concert flat roof. Internal air temperature was logged inside both spaces. Analysis of results revealed that the earth construction house performance was extremely better than the concrete house. The variation in internal air temperature inside the concrete house reached 16°C while temperature variation in the mud house was just only 4°C. Further analysis of Fathy results found that internal air temperature inside the earth construction house falls within the comfort band across the whole day while it lies outside the comfort band for 66% of the time inside the concrete house as shown in Figure 5.

Several investigations into the revitalisation of traditional building technologies in Egypt in terms of construction methods, materials and architectural character followed. Elnokaly and Elseragy investigated the revitalisation of traditional curved roofs in Aswan city which represents the hot-dry climatic design zone (Elnokaly & Elseragy, 2006). They studied the relationship between the intensity of incident solar radiation and the geometrical configuration of the roof. They confirmed that the orientations of the curved roof have a significant effect on the received solar radiation while the curved roofs seemed to be more energy-efficient. On the daily-average bases (N-S)-facing orientation, the vaulted-roof receives 66.3% from the received on the flat roof. Iscandar (Iscandar, 2006) discussed how the character of design derived from Egyptian traditional techniques could support the demands of modern requirements. He presented some neo-vernacular case studies of Michael Graves, Hassan Fathy and Ramses Wissa Wassef. This work had set some points that make the building to communicate with the users and to belong to the place. These points are; respect of the site, respect for natural environment, respect of climate and the mixing of historical and traditional aesthetics with contemporary technology and requirements. Uehuawi (Uehuawi, 2006) looked into the reintroduction of the courtyards into the contemporary architecture in Egypt. This work asserted that the new building regulations were one of the most important reasons that affect negatively the use of the courtyards. It also confirmed that providing the courtyards with movable shading devices with enough consideration to the beauty and vegetations aspects could enhance the environmental performance of the courtyards. Other work [8-13] looked into earth construction from geochemical, historical, or structural points of views. Filippi analysed the main characteristics of the urban pattern and building typologies of traditional earth architecture in two settlements of El-Dakhla oasis; El-Qasr and Balat [14]. The later investigation aimed to understand the local context of those medieval villages and how they adapted with the harsh climatic conditions of the Western Desert in order to establish appropriate conservation strategies. He confirmed that earth construction techniques can achieve the required adaptation with the harsh climate of the desert with the participation and support of the local communities.

5. Research methodology

Data were collected from the field during two study trips to the western desert in Egypt conducted during October 2006 and April 2007. The first field trip started at the west south outskirts of the Greater Cairo city going through Giza and the 6th October Governorate and then going through the western desert stopping at Baharia, Farafra, El-Dakhla and El-Kharja oasis respectively. The second field trip started at Sohag going through Assiut and ending up in El-Dakhla. Figure 1 shows the routes of the two trips. The team visited the old mud villages of El-Farafra (*aser el farafra*) and El-Dakhla (*el-aser*). The visit also included Bader museum in El-Farafra that was built using traditional earth construction techniques by the 'natural artist', teacher and mud building enthusiast Bader Abdel Moghny. We also visited Desert Lodge hotel, a modern tourist resort to the north west of El-Dakhla old village. Several concert dwellings of different sizes were also visited.

Interviews aimed to explore the potentials and constrains of using earth construction techniques and materials throughout the oasis from the technical, environmental and social points of views. Eighteen in-depth semi-structured interviews - over the two trips - were conducted with locals from four oases to discuss their opinions and experience in relation to earth construction techniques. Each interview during the first visit used a maximum of fifteen open ended questions chosen from a list of twenty nine questions covering issues grouped under the following eight categories: need for privacy, sense of neighbourhood, visual distinction between private/public, private/public thresholds, site response, social values, environmental features and transportation. Interviews during the second trip included open-ended questions chosen from a list of forty three questions covering the same issues as in the first field trip interviews. All interviewees were chosen randomly from different age groups and social backgrounds including drivers, porters, government employers and a Muslim cleric. All interviews were video taped. Transcripts were later translated and analysed.

6. Traditional earth construction techniques versus modern construction technology

Date palm and desert clay are found in abundance across the New Valley oasis from Siwa in the north to the Dakhla and the Kharja in the south. "Besides the fruit ... the date palm over the centuries ... provided (the people of the desert with) a large number of other products which have been extensively used ... in all aspects of daily

life (including construction) ... Practically all parts of the date palm, except perhaps the roots, are used (in construction) for a purpose best suited to them" [15]. Very high quality clay such as Baharia clay, Farafra clay and East-Oainat clay can be acquired without much difficulty [16]. One informant said:

> *"Everywhere in the desert you can find clay and sand. You can use them to make adobe without even having to use manure or straw* (as stabilizers) *and use the clay as mortar".*

Traditionally mud buildings in the western desert are built using sun-dried adobes known locally as unbaked or green bricks (*el-toob el-nay*) and in some cases stone were used for foundations. Timber from several kinds of local trees was traditionally used as vertical structure elements in the roofs and as wall ties, as well as doors and window frames, sill and lintels. To produce green bricks, subsoil clay is excavated manually, mixed with water, kneaded and stirred to enhance binding between the elements used. The mixture is then thrown into a wooden form and left to dry in the sun. Different types of additives were usually used to modify the characteristics of the loam being used. Straw cut (known locally as *ash*) is added to the mixture to; a) increase the binding forces of the mixture; b) decrease the shrinkage ratio; and c) reduce the appearance of cracks. Minke suggested that adding strew also enhances the thermal insulation properties of the mud [17]. Minerals and animal manure is used to stabilize loam against water erosion and to enhance the binding forces. In the New Valley, readily available chemical fertilizer (sodium phosphate Na_3PO_4, sodium nitrate Na_2NO_3, ammonium nitrate NH_4NO_3 and potassium nitrate K_2NO_3) are used. Walls are then plastered with a paste of mud and straw mixture.

Ceilings and roofs of mud buildings in the oasis as in other parts of rural Egypt were traditionally supported by timber beams produced from three types of local trees. These are; Camphor tree known locally as the *Kafoor* tree (Latin name: Eucalyptus legatensis), Casuarina tree known locally as *gazwarin* tree (Latin name: Casuarina equstifolia) and date palm known locally as *nakhl* (Latin name: Phoenix dactylifera). In some cases Cuprysus trees known locally as *saro* (Latin name: Cuprysus setercerioun) were used but mainly for windows and doors frames. In the oasis the most type of timber used for beams is produced from the date palm trees. The trunk of the palm tree is split into two halves, each is known locally as *felag (in the plural, ef'lag)* which are then put with the longer width perpendicular on the walls used as shown in Figure ??. Beams are covered by hand-woven canvas made of date palm leafs midribs or stalks known locally as *greed* (singular, *greda*). The stalks are traditionally tied together using handmade ropes made of shredded date leaflets or sheath fibre from the leaf base known locally as *leaf el-nakhl.* The robes were usually made on site in a process known locally as *fet'el*. Recently, ready made flax, kenaf, cotton or jute ropes are used instead to speedup the process and save the cost of the worker hired to make the ropes. The canvas is then covered by date palm reeds known locally as *za'af* and a layer of sun dried mud bricks is laid on top to increase the stiffness and water erosion resistance of the roof. The bricks are then covered by a paste of clay to allow using the roof for sleeping and other activities. Recently polyethylene water barrier is used under the brick layer to protect the roof from water leakage caused by occasional rain.

Openings are relatively small and sometimes are pierced with decorative brick units or fixed with unglazed timber shutters to protect the interiors from glare and hot winds. In Al-Qaser the sunt timer (Latin name: Acacia sp.) - although is not found in the western desert anymore – was used to make doors lintels that were decorated with verses from the Holly Quran. The majority of the buildings had small triangular or rectangular small openings located directly under the ceiling level to allow the dissipation of hot stagnant air accumulated inside spaces by bouncy.

Several elderly informants confirmed that years ago they were able to use different earth materials and construction techniques themselves to build their own homes. Everyone used to have enough building skills to allow building their own houses and providing assistance to relatives and neighbours. The majority confirmed that they were helping each others in building their houses and used to exchange necessary building materials.

> *"My neighbours were helping me in building my home and we did not need to bring skilled workers to work for us. We were building ourselves"* a 73 years old informant said.

However, this knowledge base and communal cooperation disappeared almost completely from the community and concert construction houses built by contractors and professional builders widely took over. All building materials used in concrete construction such as cement, aggregates, reinforcing steel and fired building bricks are all imported from various parts of the country increasing by such the overall coast of the construction and the overall the embodied energy of the building.

The fact that the old mud village for example in El-Dakhla is crumbling away, and in dire need of attention after the government had evacuated its houses - in an attempt to preserve the buildings - does not set a model to follow. Careful field observation showed several technical and social reasons that gave mud architecture in the New Valley its bad name and contributed to the decline of this traditional technology.

First, the quality of contemporaneous locally produced mud bricks is very poor. Unnecessarily stronger fired mud bricks made-up of rich top soil excavated from the Nile Valley and Delta are preferred instead. Despite being illegal to manufacture red bricks after the government had banded top soil excavation, red-bricks are still produced and transported to the oasis. One of the informants said:

> *"The old mud bricks we used to have were far better than the ones we get today as we lost our clever (meaning: skilled) workers"*

Second reason, is the need to build multi-storey houses to accommodate large extended families. Despite several of the traditional mud-brick houses found in old villages being three and four floors high (Figure 9), people do not trust the present earth technologies and skills and choose to use concrete technology instead.

Rain and underground water are always the main enemies of any mud building. Traditionally mud-brick villages across the western desert in Egypt were built on high grounds to avoid underground water erosion and occasional floods. With the increase in population, people needed to expand their villages, and they started building houses down the hill, and this is when problems started to happen. Walls were cracking due to the raising water table and maintaining the houses became difficult, laborious and expensive job. In 1991, Bawiti, a village in Al-Dakhla Oases, were flooded and most of the mud-brick houses and schools were sadly damaged leaving families living on the streets. This had caused almost all able families to build their new houses in concrete.

> *"When the water reached my house and caused it to collapse, I decided to build my new house in concrete. I had to pay for rebuilding the house anyway, so I decided to pay a bit more and end-up with a concrete house, just to be on the safe side"* one of the informants said. Another one told us *"I want a concrete roof so I can close the door and live inside no matter what is going outside. But when it comes to health (meaning comfort) the mud houses are much better. In a concrete house your children will suffer and no one can sleep in summer"* one of the informants said.

Since the Aswan High Dam was completed in the late 1960s, the water flowing downstream became silt free and the salinity of the water increased due to long-term storage in the Lake Nasser. This in addition to the excessive use of water in irrigation, had caused water logging causing the water table to rise bringing salt to the surface [18]. In the New Gourna, Hassan Fathy had used lime stone to build the foundations of mud walls to protect it from the damp. High levels of underground water caused by the Aswan High Dam, reacted with the stone (calcium carbonate) causing a substantial damage to the building's foundation and walls as shown in Figure ??. Mr Sabra, the owner of one of the three remaining house in New Gourna, who was very keen to maintain the house that Hassan Fathy had built for him, informed us that he found out through the renovation process that the quality of the stone used during the construction in the 1940s were of a very bad quality.

Finally, termites (known locally as the white ants, in Arabic *El'Namel Al Abiad*) damage the untreated timber beams causing roofs to collapse as in the case of an old mosque in Al-Qasr. The locals replaced the damaged timber beams with steel beams, but the mud walls could not endure the weight of the steel beams and cracked. People are claiming that Al-Dakhla was infected with termites when the local government brought sand and spread it over the grounds of the old village in an attempt to clean it up for a visit by one of the senior government administrators. There is no way to verify this claim.

Now two construction systems are widely spreading across the oasis: 1) bearing walls and reinforced concert slabs as shown in Figure ??, 2)concert frame structures as shown in Figure ??. In the bearing walls system, the walls are construct in fired mud bricks (locally know as *red-bricks*) 25 x 12 x 60mm or lime stone blocks (200 x 250 x 400mm) queried from the mountains to the west of the Nile Valley, both transported at least 300 miles. In situ reinforced concrete slab is then poured in a wooden formwork (imported pinewood). In few cases traditional timber roofs are used instead of the concert roofs as shown in Figure ??. In the reinforced frame system, concert is used to for the structural frame and fired red-bricks or white stone blocks are used to construct the external walls and the internal partitions as shown in Figure ??.

In the following two sections, we will discuss the environmental and socio-cultural drivers for reusing earth construction techniques.

7. Environmental dimension

The old mud towns of the oasis were characterized by their narrow winding streets which are sometimes covered as shown in Figure 8. This meant that pedestrians as well as houses are shaded for most of the time. Cold air deposits during the night are trapped in the streets that become reservoirs of cool fresh air that can be used in hotter times of the day to cool the structures and the inhabitants using Venturi action. High small clearstory window opening into the shaded street known as *"Rusha" or "Taka"* is built at high level, facing larger window on the opposite side of the space. This creates pressure difference that induces cross ventilation. Northern walls were built lower than southern walls to increase the shade and trap more of the prevailing cool wind blowing from the North West. Because the *rusha* is higher than the window, cool dense air falls down on the floor, and moves across the occupants to cooling them as it pass. Interviewees who did not ever live in a traditional house were completely unfamiliar with these passive design measures. When demonstrated to them, they doubted it could be widely doubted in modern houses due to the increasing prices of timber used for window frames, and the bulky modern furniture that minimize the areas available for windows. More importantly, increased use of cars led to wider streets to accommodate motor traffic, losing by such the whole number of environmental benefits.

Traditional mud-brick houses benefit from the heavy thermal mass of their structures that dampens the extreme outdoor conditions, keeping occupants thermally comfort for most of the year. The analysis of Al-Kharja oasis climate reveals that the use of thermal mass could increase the percentage of thermal comfort on average by 50%. All informants who moved from a mud houses to live in a concert dwelling confirmed that their new houses thermal performance is extremely poor in comparison to the old houses.

> *"mud houses are healthier* (meaning more comfortable), *the house is cool in summer and warm in winter. The concrete or block houses are hot in summer and extremely cold in winter"*.

Apart from using small openings and natural materials, all new mud houses lacks any effective traditional passive techniques such as night purge ventilation, cross ventilation, wind catchers, open sleeping areas or courtyards. Despite this newly built mud houses were reported to be more thermally comfortable as the traditional ones for most of the time without the need to use any mechanical ventilation at all apart from fans during very few hot summer days. However, occupants of modern houses are using fans during occupation hours across the year except during the three winter months. Families, who can not afford to buy or pay for operating fans, are forced to sleep outside their houses most the nights. In some cases, it was reported by several informants that families living in modern flats have to move to their parents mud houses during the summer period to escape the unbearable thermal conditions of their newly built flats.

8. Socioeconomical dimensions

Following the 1952 revolution, families from across the country and particularly from Upper Egypt were encouraged to move to the new villages of the New Valley to help increase Egypt's arable land. People brought with them their social and moral values to the oases making the social structure and patterns of the communities inhabiting the western desert very unique indeed. Privacy of the family had remain a major design requirement, with gender segregation becoming relatively less of an issue although there is always the need for a separate guest room known as *madyafa* or *mesafreen* room in case of flats (some time called *saloon*). Very rarely a private access for women is required.

The main sources of income in the oasis are agriculture; tourism; and government employment. In a country where mortgage system is still embryonic with less than handful of banks offering loans, working in any of these sectors can not - in the majority of the cases - finance building a concrete house. The cost of earth house construction is however substantially less than its concrete counterpart. Concrete technology is expensive due to the high prices of steel and cement that are always rising in an instable economical market such as Egypt where prices of reinforcing steel and cement increasing by 300% between 2006 and 2008 increasing by such the total

construction cost[1].At the time of the field study, the average total cost of a 100 m^2 mud house is in the range of £800 to £1000 compared to £8000 for the same sized concrete house[2].

Natural raw materials in the oases are abandoned in the environment. Very high quality clay can be easily acquired from the desert and palm wood and leaves are readily available. People do not have to buy earth blocks, but instead they can produce them on site. The cost of producing 1000 bricks on site is equivalent to just £3.5. This includes the cost of clay transportation and the unskilled workers required to mix the clay and form the blocks. For example, a 3000 x 4000 x 500mm mud wall will require 5000 bricks costing about £17 while the same wall area constructed of red bricks will cost just over £??. What increases the total cost of mud houses is perhaps the cost of doors and windows as well as floor tiling that has to be imported from outside the oasis. The maintenance of mud houses is also not expensive and it is only required when an accident takes place. On average, the maintenance of an average mud house is required every two years and it would costs about £100. One informant said:

> *"It (mud houses) does not need maintenance, only simple things, and only when an accident occurs, for example when a pipe bursts under a wall or a lot of rain that ruins the roof. But usually nothing needs done. If maintains is required, it is very cheap as we use natural materials from the environment. Everybody has palm trees that they can use for construction"*

Despite all the above, the majority of the oases inhabitants are very keen on using reinforced concert for social reasons. Although almost everyone we meat was aware of the good qualities of earth buildings, the majority believed that mud houses are not suitable any more for their modern needs. Older generations had spent the majority of their lives in mud built buildings; some dating to the 16th century thus they appreciate the values of earth materials and construction techniques more than the younger generations or the families immigrated to the New Valley from modern towns or cities. Although younger generations witnessed mud buildings on their door steps withstanding the test of time surviving hundreds of years, they do not share the same views with their ancestors. When asked about the reasons that led to the decline of earth construction, the majority of informants reported that concrete houses are better because they are more 'robust', 'modern', 'neat', and 'clean'. However, between the lines, it was very clear that social pressures are perhaps playing more profound role in shaping the inhabitants views.

The number of individuals working in big cities or perhaps in the capital or at one of the oil rich Arab Gulf countries is increasing. Others are heavily involved in tourism industry which is very lucrative business; also manage to secure some savings. Young men and women frequently visit Cairo and other urban cities for work, education or leisure more than ever, where all buildings are constructed using modern building systems. On returning back to the oasis, they find themselves uncomfortable with the context they grow up in, and seek modern solutions or should we say 'modern appearance'. The media also had influenced their views with more houses than ever having access to tens of free satellite television channels with mixed programs from Western and Arabic countries. "This communication revolution in satellite media has greatly influenced (their) ... tastes and choices" [19]. In a country where 69.4% of adults over 15 years and 57.3% of women are illiterate [20], TV remains an important

[1] It is to be noted that by the time this paper is published, the price of the British pound in front of the Egyptian pound had fallen by 23% following the credit crunch

[2] price of the land is excluded in both cases

vehicle for communication, education and entertainment. On one hand, concrete houses became a sign of modernity and a way of showing off wealth, and on the other hand, mud houses became associated with poverty and peasants. Their inhabitants are assumed to be *bi'a* or *balady*; a derogatory term for those of a lower social level. People are concerned to be criticised and deemed as 'poor' and 'low life' if they live in a mud house as one of our informants said:

"I am afraid that people will criticise me. If I build or live in a mud house, everyone will say I am socially retarded".

In some cases, people build a concrete extension to their traditional mud houses just for receiving and greeting their guests, while continuing to live in the mud built area.

In their desire to gain higher social status, young women refuse to marry men who do not own a 'concrete' house. For them, the concrete house is a mean of expressing the financial status of their groom and their social distinction. This had pushed all young men seeking marriage to aspire to build a concrete house increasing the average marriage age of both men and women; a social problem in a religious community which does not allow sexual relationships outside marriage. An example is our minibus driver, a 23 years old young man, who drove us from El-Kharja to Luxor. He has to work extended hours every day of the week to be able to finish building his dream house he started building on a plot of land provided by the local government that subsidizes land prices in an attempt to support the younger members of the society. He could otherwise have finished the house and started his family if he had used alternative technologies such as earth construction techniques. A father of a young man from El-Kharja justified this attitude by saying:

> *"They are just youth* (meaning: young) *and they - especially girls - are constantly watching* (meaning: aspiring to or envy) *what others are doing. They want to have what their fellow friends have got"*. Another informant said: *"All the girls in the area prefer concrete or brick houses* (meaning: houses built using fired bricks). *In their culture mud is only for the poor"*.

Several interviewees said that 'mud' is not widely used in contemporary buildings because the technology was never developed. They believe that mud buildings do not look 'innovative' or 'beautiful' or can even be fitted with modern amenities such as telephone lines, proper electric fittings or modern bathrooms. The following account is particularly illustrative:

> *"Mud buildings look the same since the Romans time! They have not been developed since then. People are fed up and want to own modern homes that look nice and can be furnished properly* (meaning: furnished richly)".

Despite this, everyone confirmed that they are looking forward to see new technologies that would make earth buildings look 'neat' and 'modern' and agreed that this would attract lots of people. One interviewee said,

"if there is a new style or technique that can produce earth buildings that look stylish and chic, people will definitely accept it".

The people of the oases - especially who works in the tourism industry - are aware that preserving the architectural identity of their villages is essential for their economical sustainability. They can foresee how this could encourage tourism that will accordingly boost the economical growth of their businesses. Those who were aware of this prospect showed great enthusiasm and commitment to earth construction. An example is Mr. Abdel Hamead from El-Dakha who was brought up in the old village of Al-Qasr. He developed a resort to the north of Al-Qasr old village completely of mud. He proudly showed us around his resort, which to a great extent had resolved several

technical and design issues in relation to the earth construction technology. He had also developed a new mud house for his family down the hill after his family was evacuated from his family house. Mr. Abdel Hamead invited several families from Al-Qasr to visit his resort and house in an attempt to encourage them to adopt the same approach. However, when we referred to those two examples in our interviews, almost everyone expressed the same view. Although they can all see how the majority of technical issues they were facing had been resolved neatly in Abdel Hamead's lodge and house, they strongly believe that this did come cheep and said they can not afford financially to go through the same route. In the same time they see that building with *el'belok* (lime stone blocks) or *kharasana* (reinforced concert) is much quicker. They are not willing to make the effort to build or maintain mud houses and would rather prefer to pay more for a builder to do the job for them and to have a maintenance free house. They all made statement like:

"when the white blocks were introduced, of lives easier were made easy".

9. Conclusions

The lack of experience of contemporaneous oasis inhabitants and the obvious ill support from the Egyptian Antiquities led to the deterioration of traditional earth buildings as the case with Al-Qasr. This among other factors discussed in the paper had led to the decline of the traditional techniques. It is very clear from the discussions with the public that there is a need to initiate a debate within the community in relation to the social potentials of earth construction and what is considered to be 'modern'.
Six main conclusions from this work can be drawn as follows:

1. The thermal performance of earth buildings is better than the other construction types in the Egyptian western desert. This was suggested by the objective response of inhabitants;
2. Technical problems in relation to using earth construction techniques such as the sensitivity and weak resistance to water could be easily overcome with affordable and local techniques;
3. Earth construction house is much cheaper than its concrete counterpart;
4. Reintroducing earth construction techniques could not be achieved without overcoming the social constrains. The public have to learn more about the benefits of earth construction techniques. Building prototypes could be one solution;

10. Further work

Further work will investigate the potential of applying new earth construction techniques including prefabricated rammed earth panels in complex buildings and compressed air blocks in mainstream primary schools.

11. Acknowledgments

All the thanks are due to the interviewees who welcomed us in their homes and provided us with their insightful ideas. Mr. Osman and Mr. Mohamed would also like to thank the Egyptian Ministry of Higher Education for the full PhD scholarship they were granted. Mr. Osman and Mr. Mohamed are members of staff of Al-Minya and Zagazig

Universities on a sabbatical leave funded by their universities. They would like to thank the Egyptian Education and Culture Bureau in London for its effort in managing their scholarships. They are grateful for Dundee School of Architecture for the continued support they are receiving.

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13. Figures

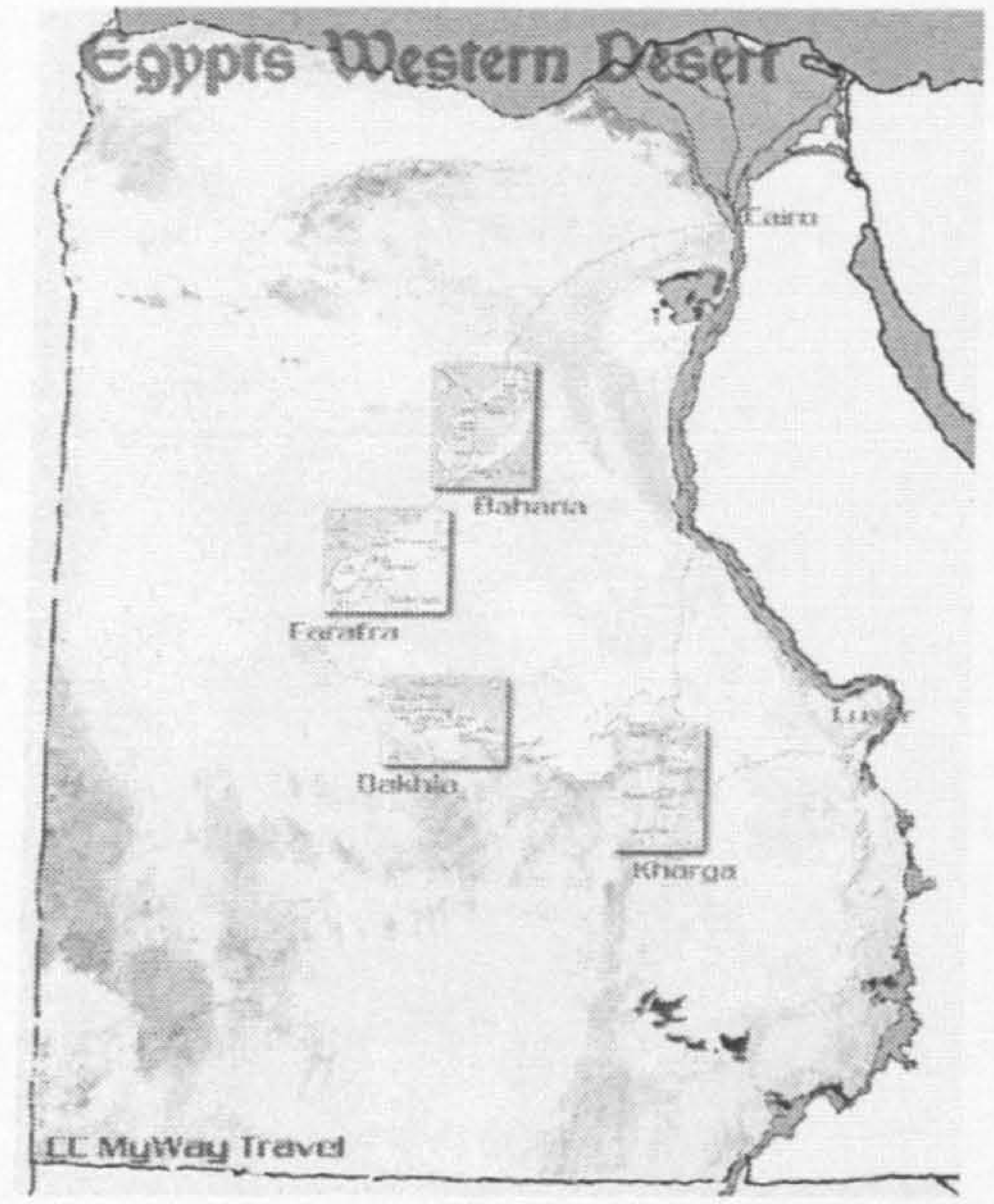

Figure 1: The western desert of Egypt [21]

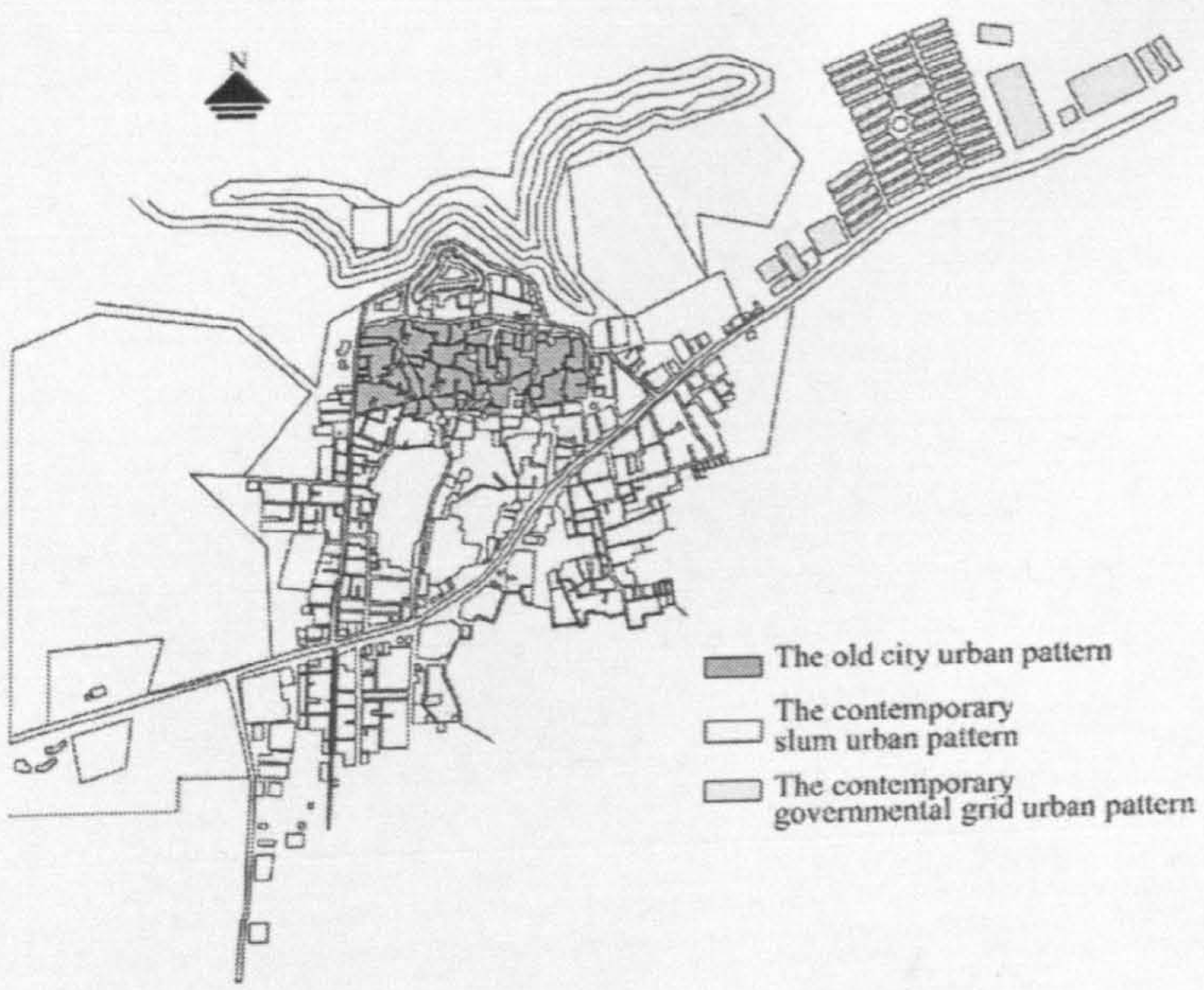

Figure 2: Old and new urban pattern in AlKasr, Dakhla, after [22]

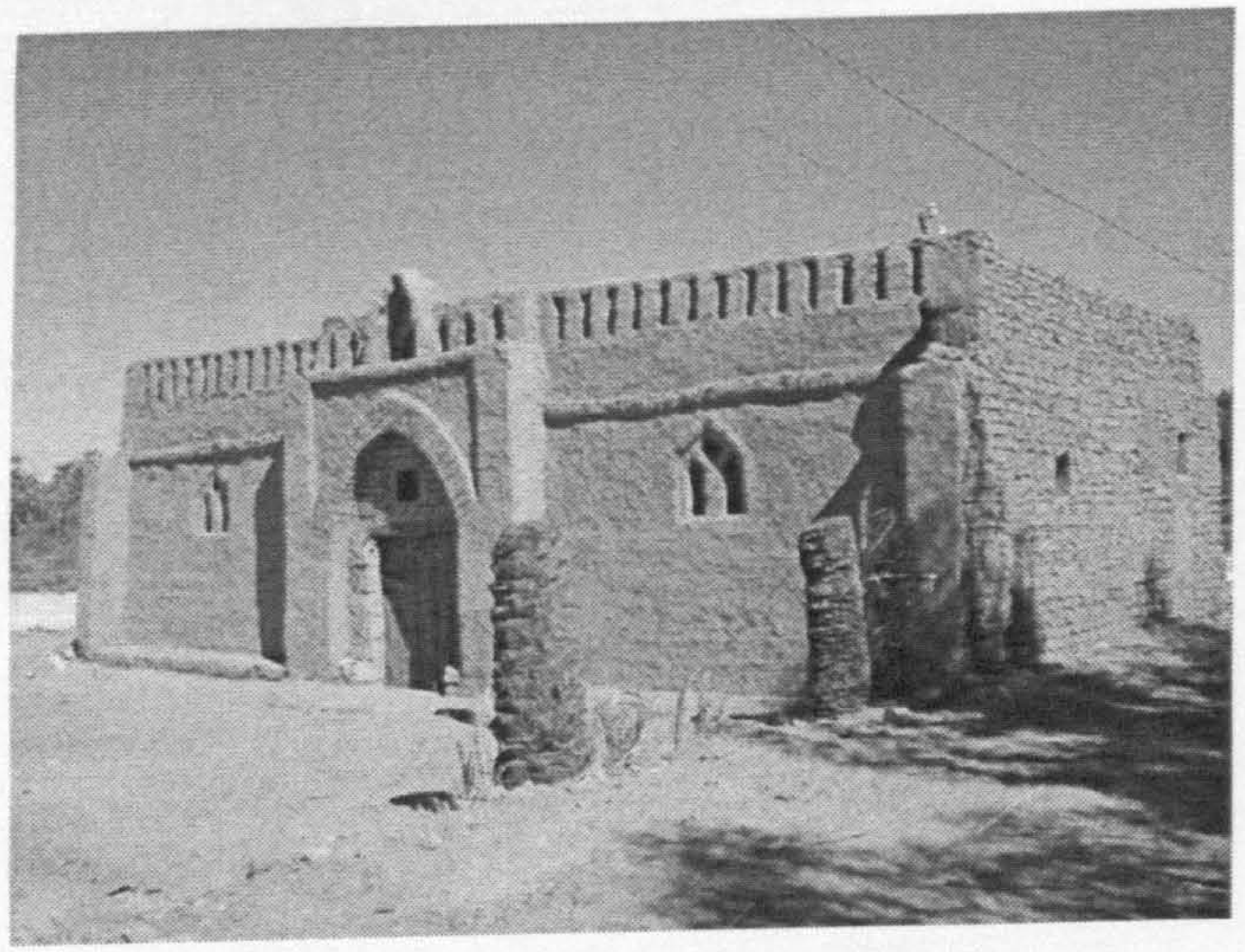

Figure 3: Traditional house in AlKasr - Dakhla

Figure 4: Concrete and white blocks in Dakhla

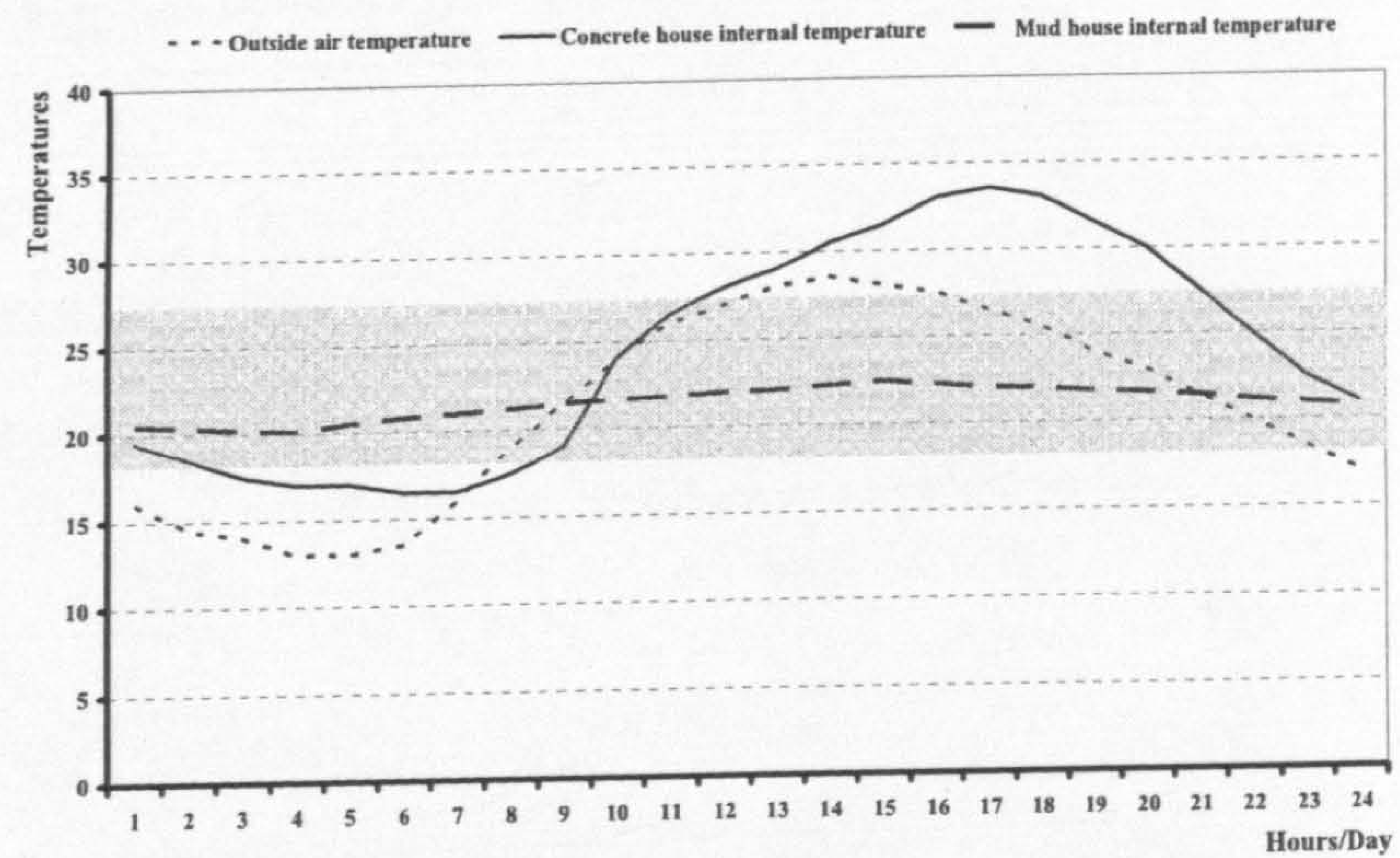

Figure 5: The internal air temperature in two earth construction and concrete buildings, after [4]; The grey are is the comfort band of Cairo

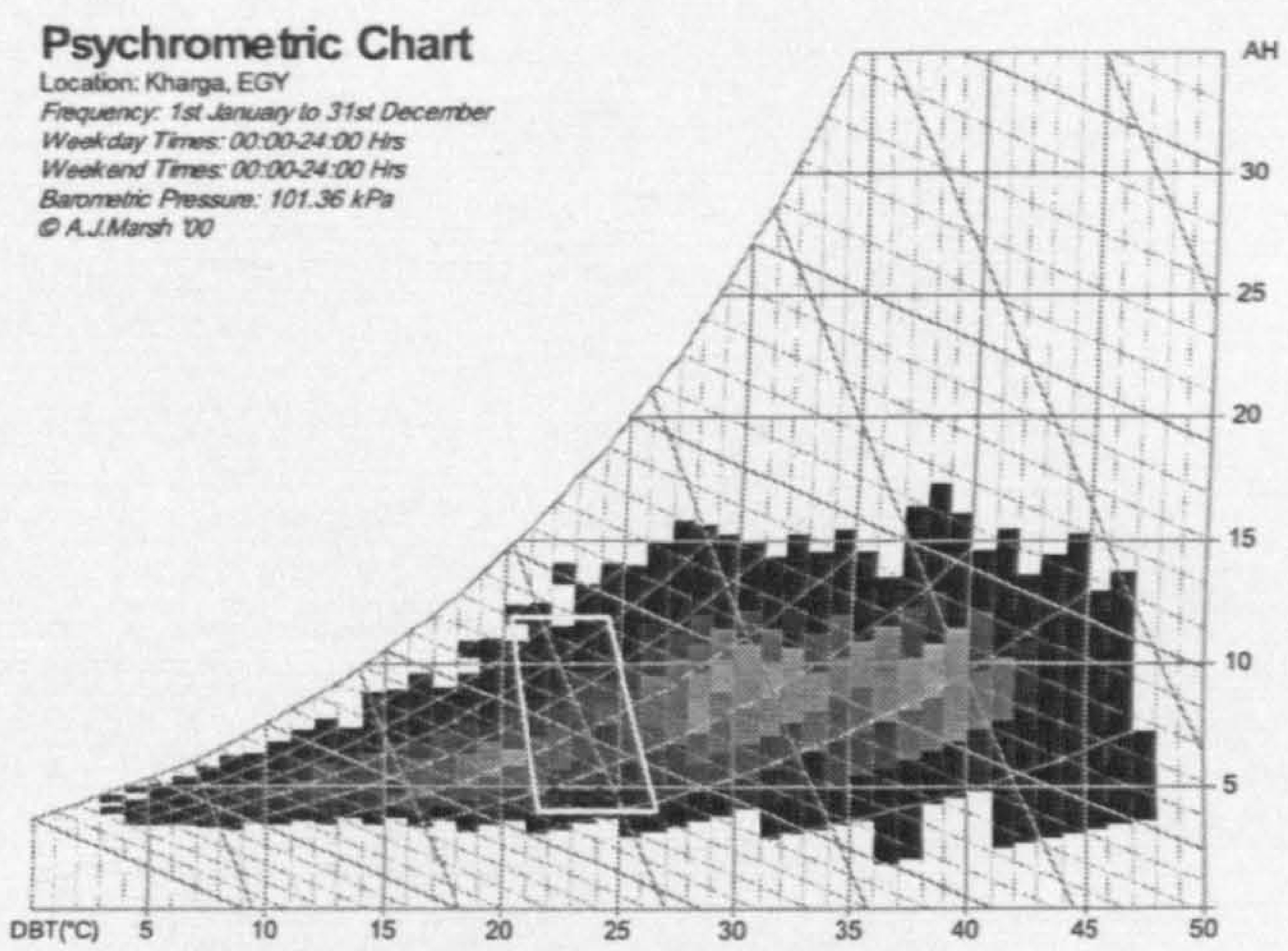

Figure 6: The average comfort zone for the whole year in Al-Kharga

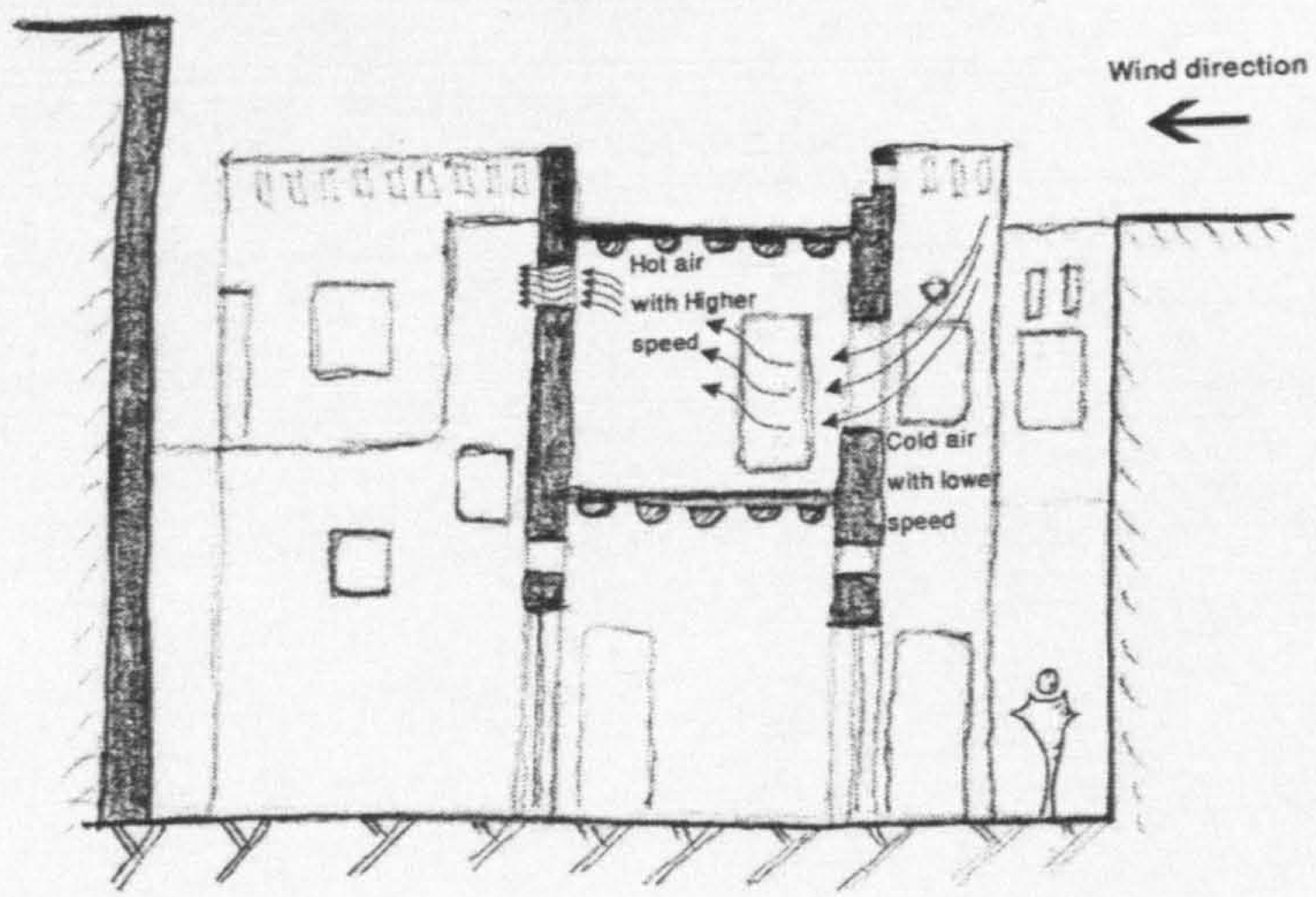

Figure 7: Effect of the "Taka" on the cross ventilation

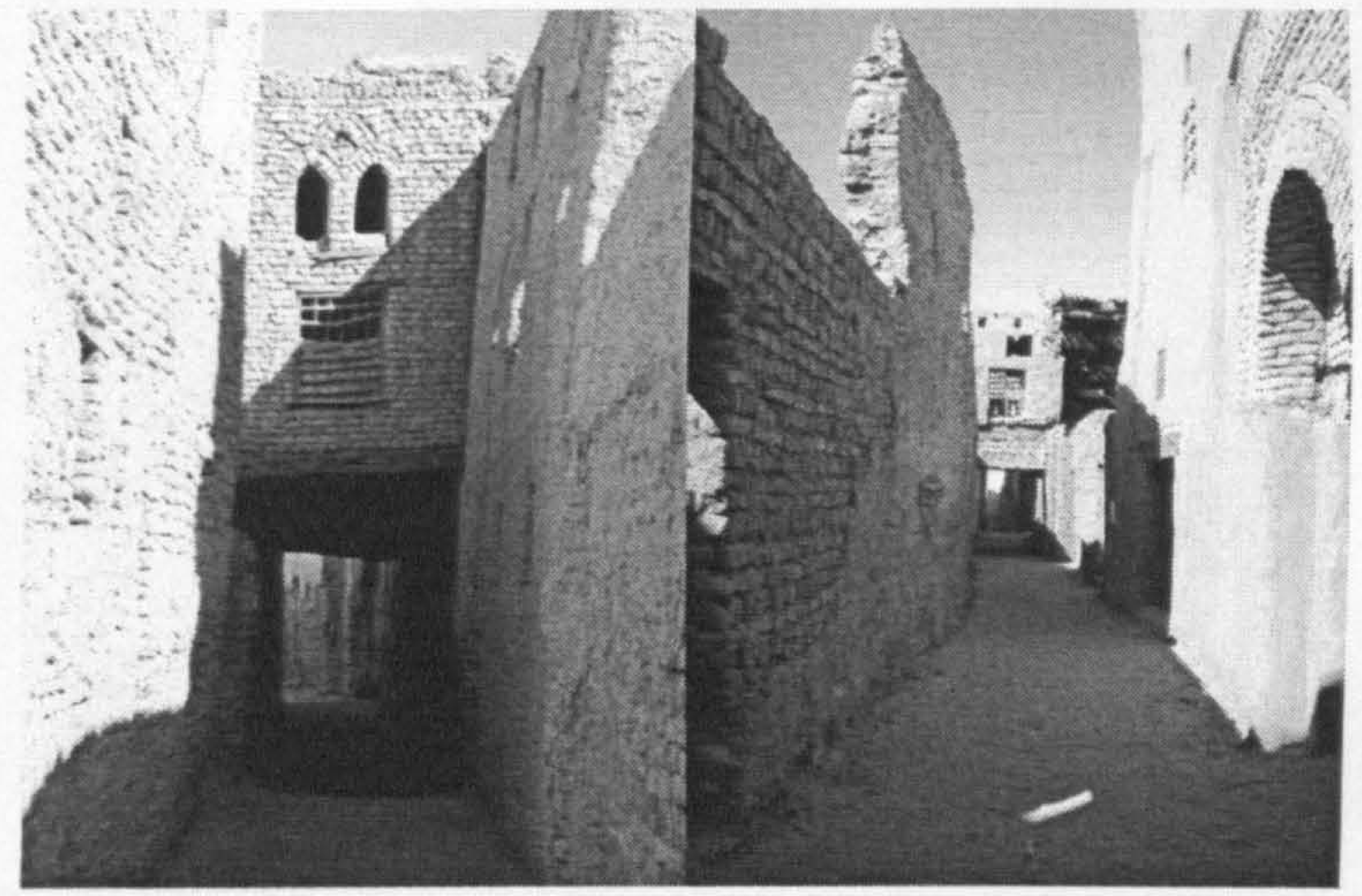

Figure 8: Shaded streets in the old cities in Western desert (Alkasr in AlDakhla)

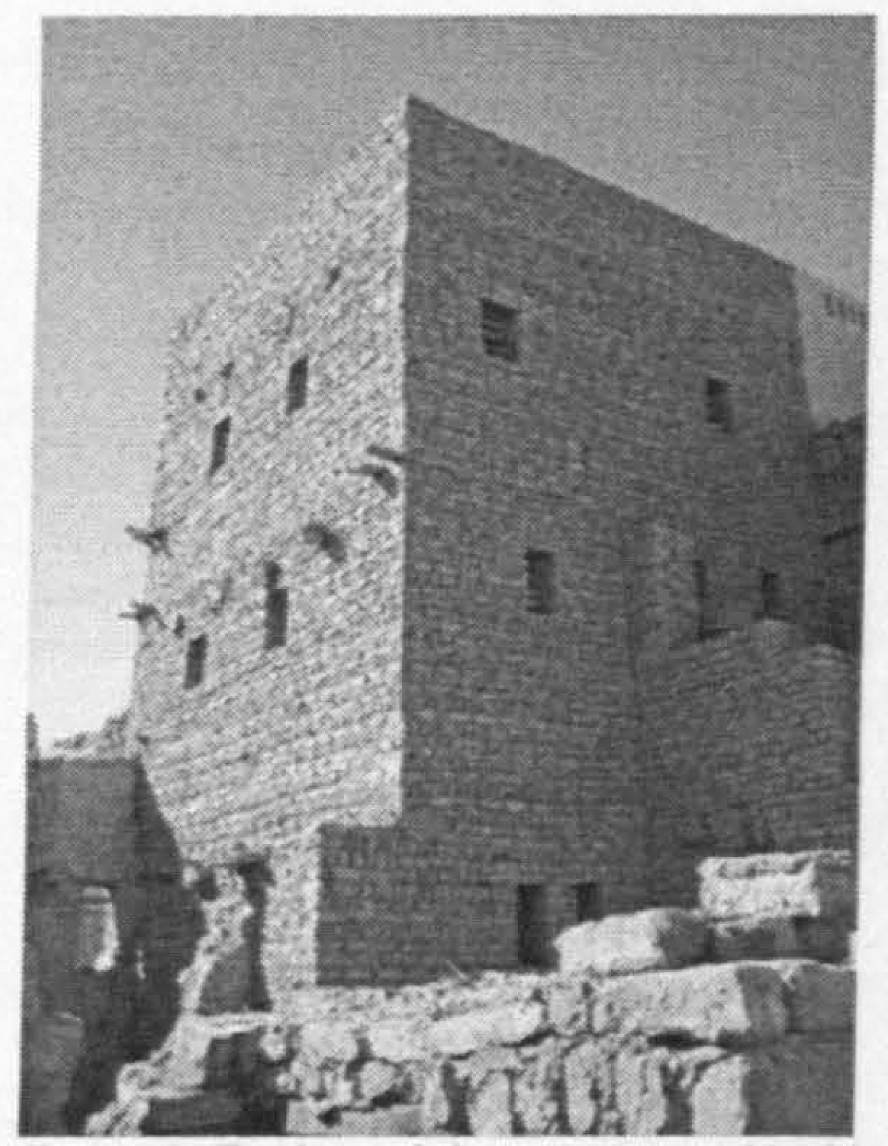

Figure 9: Traditional three stories mud building

Figure 10: building walls using mud

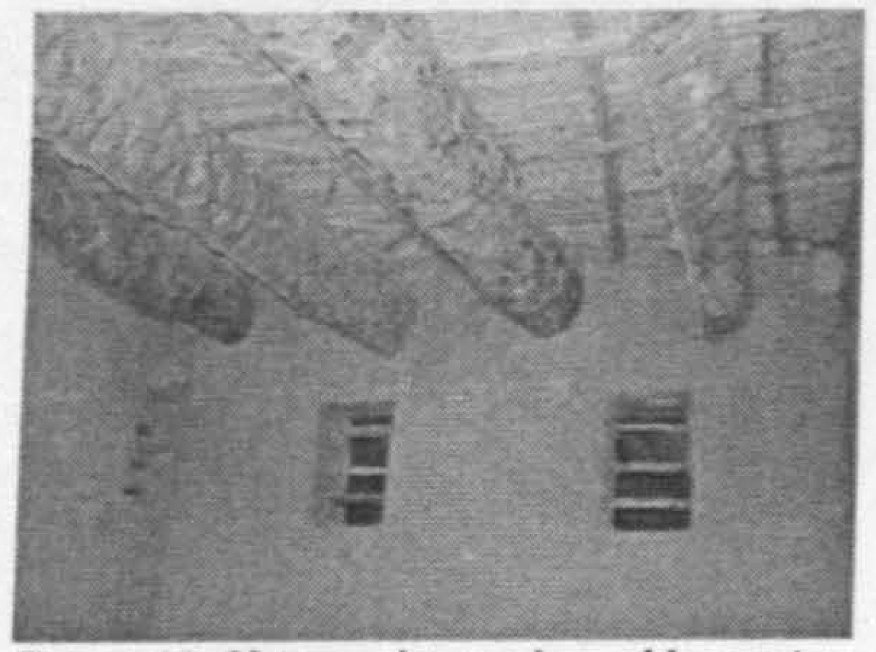

Figure 11: Using palm trunks and leaves in roofs

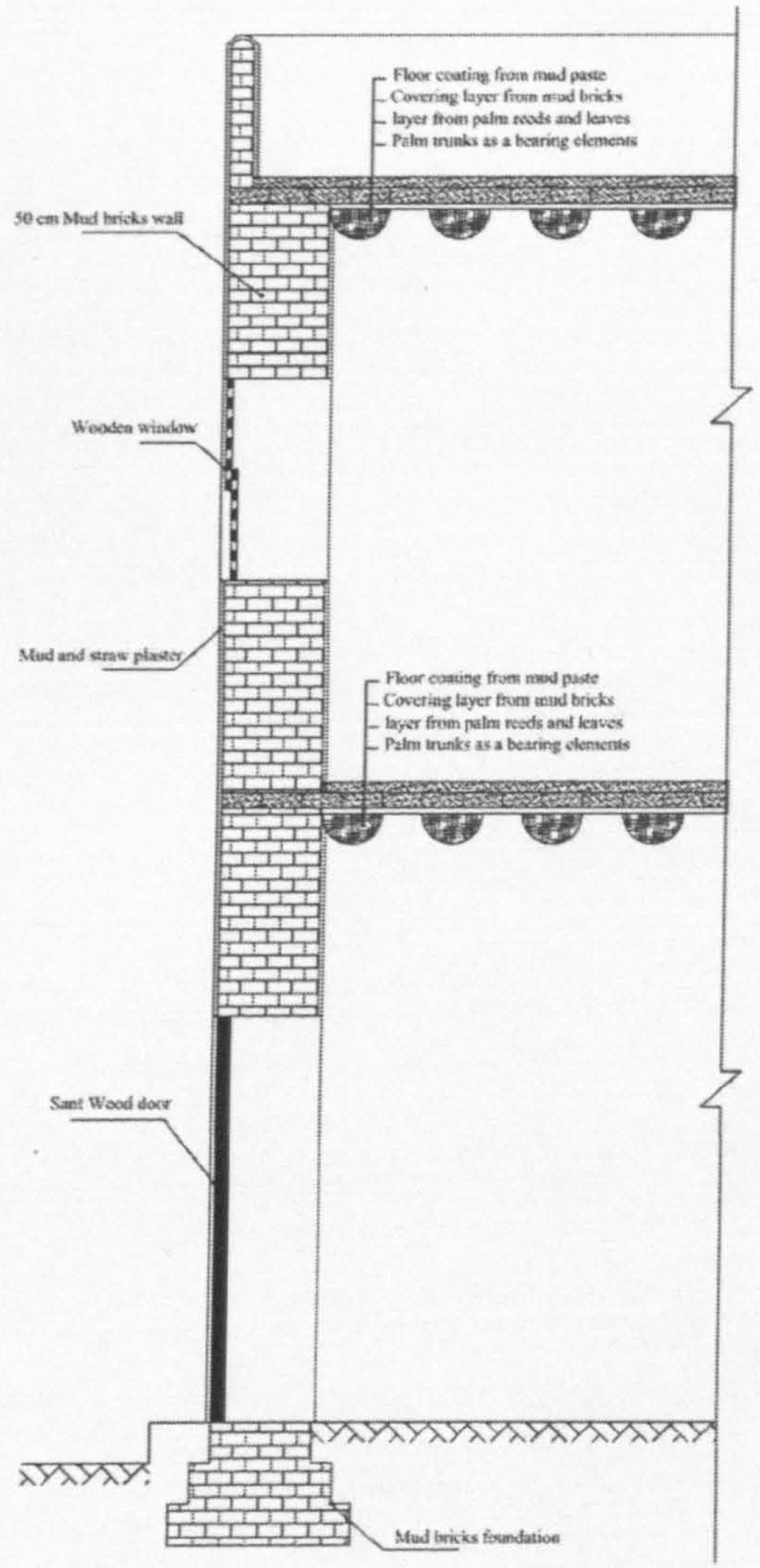

Figure 12: Vertical section in a house constructed in earth techniques